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A New Ranunculus Disease Caused by *Xanthomonas campestris*

H. R. Azad and **M. Vilchez,** Staff Research Associates, **A. O. Paulus,** Plant Pathologist, and **D. A. Cooksey,** Professor, Department of Plant Pathology, University of California, Riverside 92521

ABSTRACT

Azad, H. R., Vilchez, M., Paulus, A. O., and Cooksey, D. A. 1996. A new ranunculus disease caused by *Xanthomonas campestris*. Plant Dis. 80:126-130.

A new disease of ranunculus (*Ranunculus asiaticus*) was observed on several cultivars in commercial fields in San Diego and Riverside Counties, California. Symptoms included pin-point to large irregular necrotic lesions on leaves and stems and occasionally black patches along the internal margins of leaflets in association with vein chlorosis. *Xanthomonas campestris* was consistently isolated from diseased tissues. *X. campestris* was also isolated from tubers and seeds of naturally infected plants, which suggests a means by which the pathogen is spread in the industry. One-year-old tubers of two cultivars (Picotee and Rose) were contaminated at frequencies of 4 and 7%, respectively. The frequency of seed contamination for 11 cultivars ranged from 1.1 to 16%. Symptoms appeared on inoculated ranunculus plants as early as 3 and as late as 22 days after inoculation, depending on the method of inoculation, temperature, and available moisture. Recovery of the bacterium from the tubers of plants inoculated and kept under different moisture and temperature conditions was 6.6 to 13.3%. Amplification of a DNA fragment specific for *hrp* genes by polymerase chain reaction for each strain and further analysis of the amplification product by restriction endonuclease digestion suggested that the ranunculus strains were closely related to each other and to *X. c.* pv. *campestris*; however, pathogenicity tests indicated that the ranunculus strains could be a different pathovar.

Ranunculus (*Ranunculus asiaticus* L.) is increasing in California as a field-grown bulb and cut flower crop. Ongoing variety selections are made by collecting seed from plants with desired flower color and growth habit, and the seeds are used to propagate plants for production of root tubers and for cut flowers. In January 1994, a ranunculus plant with a foliar disease was sent to our laboratory from a commercial grower in Palm Desert, California. Concurrently, an outbreak of a similar disease was observed in commercial fields in San Diego County, especially in the Carlsbad area. Symptoms of the disease from different areas included irregular necrotic lesions on leaves and stems (Fig. 1B and C). Lesions were often associated with a chlorotic halo or general leaf yellowing, but water-soaking was seldom associated with lesions. More advanced phases of the disease included coalescence of the lesions, complete necrosis, and death of leaves (Fig. 1D and E), and eventually collapse of the entire plant. Occasionally, black patches along the internal margins of leaflets in association with vein chlorosis were observed (Fig. 1F). This report describes the isolation and confirmation of *Xanthomonas campestris* as the causal agent of this new disease.

Corresponding author: D. A. Cooksey
E-mail: Cooksey@ucrac1.ucr.edu

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MATERIALS AND METHODS

Isolation of causal agent. Tissue sections from lesions on original or inoculated diseased leaves were crushed in 0.5 ml of sterile distilled water (SDW). The resulting suspension was streaked, or plated in dilutions, onto MGY (8), YDC (17), Tween (11), and MS (12) media. Some naturally infected and some asymptomatic plants were collected from Carlsbad and brought into the laboratory. The root tubers (bulbs) were washed under running tap water to release soil particles. The roots were then chopped into 5-mm pieces and added to 100 ml of sterile saline containing five drops of Tween 20 in a 250-ml Erlenmeyer flask. Flasks were placed on a shaker with vigorous shaking overnight at 4°C. The liquid content of each flask was concentrated by centrifugation, and the pellet was suspended in 1 ml of SDW. Serial dilutions were plated onto YDC and Tween media. Several tubers were also cut with a razor blade, and small tissue pieces from internal necrotic areas were excised and treated as the leaf tissues described above. Dried tubers of cultivars Rose and Picotee from the previous year were ground with a mortar and pestle, soaked in saline containing Tween 20, and processed as described for the fresh tubers. To initially isolate the pathogen from seeds, 1,000 seeds from cultivar Salmon 93 were soaked in 25 ml of saline with Tween 20 overnight at 4°C. The liquid portion was concentrated and plated as described earlier for tubers. Later, 1,000 seeds (Mellano & Company, San Luis Rey, CA) from this cultivar and from 10 other cultivars were individually plated on Tween medium. Plates were incubated at 28°C for 1 week. The strains recovered from each isolation were purified by streaking single colonies on fresh media at least four times.

Identification of the bacteria. Tests for identification of the strains were performed as described by Schaad (13). The strains were also compared by their carbon source utilization profiles on Biolog GN microplates (Biolog, Inc., Hayward, CA). *X. c.* pv. *campestris* 0186-1 (from cauliflower), *X. c.* pv. *vesicatoria* 0788-2 (from tomato), and *X. c.* pv. *translucens* 0790-9 (from wheat) were used as controls.

Plant preparation. To obtain pathogen-free ranunculus plants, individual seeds from cultivar Salmon 93 were plated on Tween medium and incubated at 28°C for 5 days. Seeds that tested negative for the presence of the pathogen were then individually planted in 10-cm (4-in) pots containing steam-treated UC soil mix (4). Pots were placed in a growth chamber with a constant temperature of 16°C, a relative humidity that fluctuated between 50% (at 2 to 5 p.m.) and 100% (at 2 to 6 a.m.), and 10 h/day artificial light. After seed germination, the temperature was raised to 20°C, and the photoperiod was increased to 12 h. Seedlings were inoculated after they reached the five- or six-leaf stage.

Plant inoculations. Bacterial colonies of ranunculus strains and other pathovars of *X. campestris* were grown on YDC agar for 48 h at 28°C and suspended in SDW. The suspensions were diluted to about 10^7 CFU/ml, based on optical density readings with a Klett-Summerson colorimeter, which were confirmed by dilution plating on YDC agar. The bacterial suspensions were infiltrated into leaves of tobacco plants (cultivar Turk) with a needleless syringe. Observations for hypersensitive reactions were recorded daily for 7 consecutive days. One-month-old cauliflower

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Methyl Bromide Gas Treatments of Dormant Gladiolus Corms and of Sclerotia of Sclerotium rolfsii. T. R. CARPENTER AND EARLE T. GAMMON.[1] In January, 1954, the Bureaus of Plant Pathology and Entomology, California Department of Agriculture, conducted tests designed to ascertain the tolerances of dormant gladiolus corms and of mature viable sclerotia of *Sclerotium rolfsii* Sacc. to methyl bromide (bromomethane) gas. These tests were made to determine whether or not methyl bromide could be used in eliminating *S. rolfsii* from gladiolus corms grown in a commercial planting where this fungus was found to be present. Corms and sclerotia were treated simultaneously with methyl bromide gas at rates of 3, 5, 7.5, 10, 15, and 20 lb. per 1000 cu. ft. of air space in the treatment chamber. Each treatment was conducted at 27°C and relative humidity of approximately 60 per cent for 4 hours. About 15 days prior to the gas treatments, the corms had been treated for 30 minutes in a 1:1000 aqueous solution of mercuric chloride. The sclerotia, including checks, were treated in a 1:1000 aqueous solution of mercuric chloride for 30 seconds then dried before preparation for the gas treatments.

Dormant corms, 1200 each of the varieties Burma, Cordova, Florence Nightingale, and Snow Princess, were furnished by a commercial nursery. At each gas concentration treatment, 100 corms of each variety were treated and 100 were set aside as untreated checks. Following each treatment, the excess gas was allowed to escape from the corms by airing. The corms were planted by the nurseryman within 21 days after treatments.

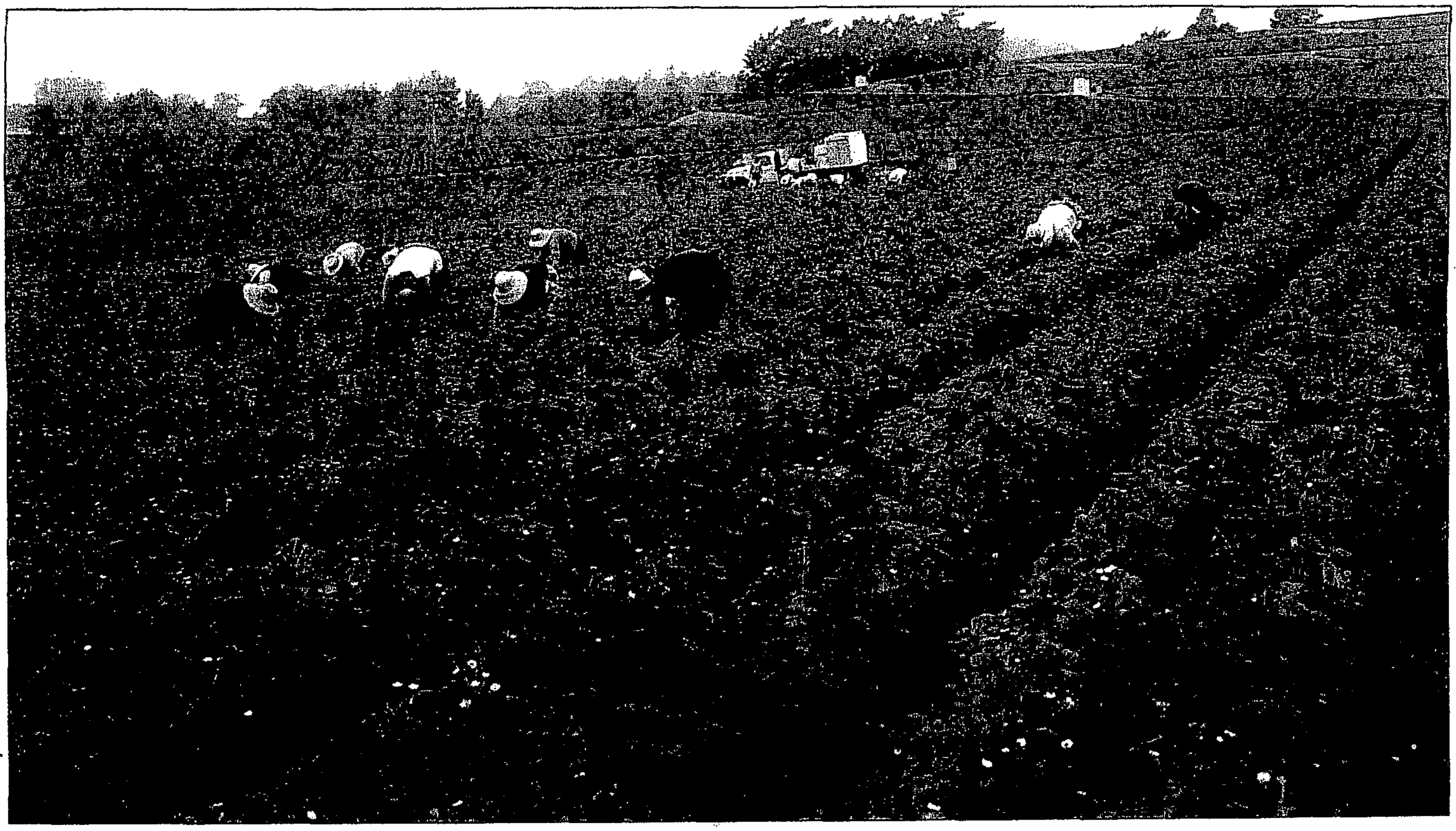
In November, 1954, the nurseryman reported the following results of the gas treatments given the corms. No apparent differences were observed in emergence, growth, or production between the checks and the corms treated at gas concentration of 3 lb. per 1000 cu. ft. From 0 to 10 per cent emergence was noted for the corms that had been treated with 5, 7.5, and 10 lb. per 1000 cu. ft. A varietal difference also was reported. A stimulation was noted for these emerged plants. No corms grew which had been treated with 15 or 20 lb. per 1000 cu. ft., and partial to total breakdown of them was noted at planting time.

In the preparation of the sclerotia of *S. rolfsii* for each gas-concentration treatment and for checks, 20 sclerotia in sterile Petri plates, 1 plate per preparation, were used for each of the following preparations: 1) dry sclerotia; 2) sclerotia maintained moist on filter paper saturated with distilled water; 3) sclerotia seeded on potato-dextrose agar, pH 5.6; 4) same as preparation 3; and 5) untreated sclerotia. The Petri plates that were gas treated were uncovered during treatment and for a short time immediately afterward in order to allow the gas to escape. All preparations were replicated 4 times. Sclerotia from preparations 1, 2, 3, and 5 were immediately transferred to fresh potato-dextrose agar in Petri plates and incubated for 5 days at 30°C, then held at room temperature for an additional 15 days. Sclerotia from preparations 4 were incubated for 5 days at 30° without removal from the media on which they were gas treated; after the 5-day incubation, approximately ½ of the sclerotia from each of the 4 replications were transferred to fresh media in order to test the influence of the treated media.

Of the 480 sclerotia used as checks, 478 were viable. The sclerotia exposed to the gas in a dry condition at all gas concentrations (preparations 1) were not significantly different from the checks; 464 of the 480 treated proved viable. The sclerotia exposed to the gas on water-saturated filter paper (preparations 2) were not significantly different from the checks for the gas concentration treatments of 3, 5, 7.5, and 10 lb. per 1000 cu. ft.; however, only 34 of the 80 sclerotia treated at the 15-lb. rate survived, which was significantly different from the checks, and no sclerotia of this preparation survived the 20-lb. treatment. The sclerotia exposed to the gas treatments on potato-dextrose agar and then transferred to fresh media for incubation (preparations 3) were not significantly different from the checks for treatments of 3, 5, 7.5 and 10 lb. per 1000 cu. ft.; no sclerotia of this preparation survived the 15- or 20-lb. gas treatments. No sclerotia of preparation 4, exposed to the gas treatments on potato-dextrose agar and incubated on the same media, survived any gas treatment; viability could not be demonstrated in those that were transferred to fresh media following the 5-day incubation. Preparation 4, however, is not applicable to practical methods of treating corms.

These tests demonstrate that dormant gladiolus corms will not tolerate treatments with methyl bromide gas at concentrations necessary to kill sclerotia of *S. rolfsii*.—Bureau of Plant Pathology and Bureau of Entomology, California Department of Agriculture, Sacramento, California.

[1] Respectively Associate Plant Pathologist, Bureau of Plant Pathology, and Economic Entomologist, Bureau of Entomology, California Department of Agriculture, Sacramento.



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Township limits on 1,3-D will impact adjustment to methyl bromide phase-out

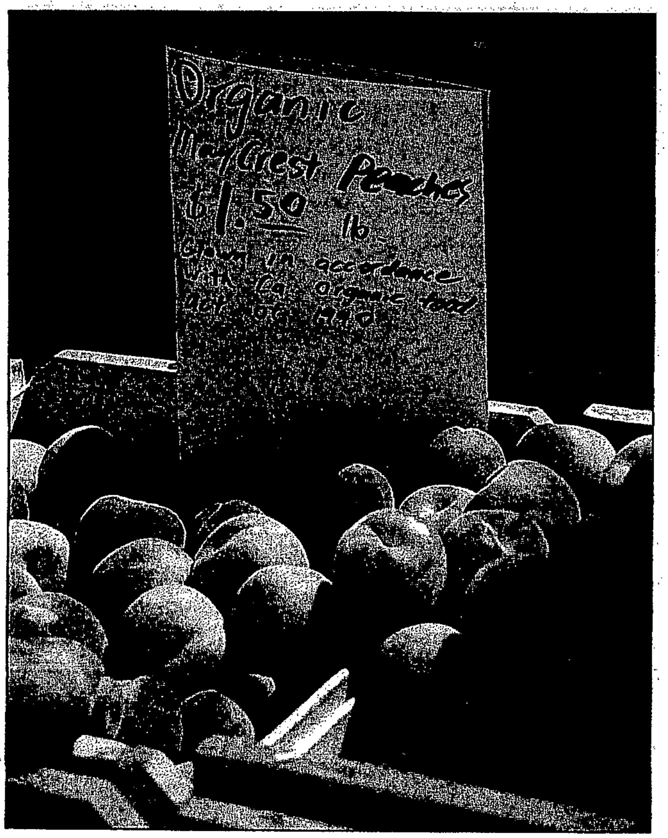
Janet Carpenter ❑ Lori Lynch ❑ Tom Trout

Methyl bromide, a popular and effective crop fumigant, is being phased out in the United States and globally because of impacts on the ozone layer. Demand for a replacement chemical, 1,3-D (Telone), is expected to increase by up to 500% when methyl bromide is no longer available. However, not all California growers will be allowed to use 1,3-D, as its use has been restricted within townships to address air quality concerns. We estimated the impact of 1,3-D use restrictions after methyl bromide is phased out in 2005 and found them to be binding in several major production areas of California. Impacts will be greatest in regions where strawberries and perennial crops are grown.

Methyl bromide, an agricultural and structural fumigant, is widely used in California to control crop diseases, nematodes and weeds. In 1992, it was identified as a class I ozone depletor under the Montreal Protocol (1992), an international treaty to reduce ozone-depleting substances worldwide. This announcement resulted in regulation of methyl bromide in the United States under the Clean Air Act, which requires the phase-out of a substance within 7 years of the determination that it is a class I ozone depletor. All production and importation of methyl bromide was to be banned by Jan. 1, 2001. However, in 1998, the U.S. Congress amended the Clean Air Act to harmonize the U.S. phase-out with the international schedule under the Montreal Protocol, with reductions of 25% by 1999, 50% by 2001, 70% by 2003 and 100% by 2005.

Methyl bromide is also subject to regulations specific to California. Since 1992, the use of methyl bromide has been restricted through discretionary controls set at the county level. The California Department of Pesticide Regulation (CDPR) recently finalized regulations to codify many county-level restrictions into state law. In addition, the new state-level regulations increase requirements for notifying neighbors prior to methyl bromide fumigation and impose more restrictive buffer requirements around application sites. These new state regulations are limiting the use of methyl bromide in some areas, even before the phase-out under the Montreal Protocol.

Cost-effective alternatives to methyl bromide are sought for crops such as strawberries, perennials, watermelons, tomatoes, lettuce and nursery crops. Researchers have identified



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◀ **Strawberries are the largest single user of methyl bromide in California, with more than 90% of acreage treated. After methyl bromide is phased out in 2005, the authors expect many growers to choose alternative fumigants such as 1,3-D and chloropicrin, metam sodium or dazomet.**

▲ **The authors estimate that at least 173 acres of peaches would be affected by township limits on 1,3-D.**

1,3-dichloropropene (1,3-D; trade name Telone), either alone or in combination with other chemicals such as chloropicrin, as the most effective alternative to fumigation with methyl bromide in terms of the lowest per-unit cost (Carpenter et al. 2000). However, researchers and policy-makers express concern about the wide-scale availability of 1,3-D as a replacement for methyl bromide, due to restrictions on its use.

California suspended the use of 1,3-D in April 1990 after monitoring detected levels above air quality standards in Merced County. In December 1994, the state reinstated its use with several restrictions. Current restrictions limit total 1,3-D use within 36-square-mile areas, known as townships. Additional practices are also encouraged to minimize levels of 1,3-D in ambient air. These restrictions are intended to address the air quality concerns that led to its cancellation.

1,3-D use in California

Agricultural producers applied over 3 million pounds of 1,3-D in California in 1999 on a wide variety of crops (fig. 1) (CDPR 1999a).

Applied as a soil fumigant, 1,3-D acts primarily as a nematicide but also controls viruses, bacteria, soil insects and fungi. Carrots accounted for nearly 30% of this use. Tomatoes were the next largest single crop use. Perennial crops, including grapes, almonds and walnuts also account for a large portion of 1,3-D use. For some of these crops, growers might choose to use either methyl bromide or 1,3-D, depending on pest pressure, soil type and cost. For example, grapes, almonds and walnuts are also among major methyl bromide–using crops.

State guidelines. In 1994, CDPR issued suggested permit guidelines to county agricultural commissioners for the use of 1,3-D. These guidelines have been modified several times with the latest ones issued in 1999. Current restrictions include a limit on the total amount of 1,3-D that may be applied within each township, depending on the depth and timing of applications (CDPR 1999b). A total of 90,250 pounds of 1,3-D per township is allowed if all applications are made to a depth greater than 18 inches between February and November. The limit is reduced if applications are made at shallow depths of less than 18 inches or during December or January. The lower limits are calculated by counting each pound applied at a shallow depth during February through November as 1.9 pounds. Similarly, the amount of 1,3-D used is weighted more heavily for applications during December or January. These practices are intended to minimize levels of 1,3-D in ambient air. If all applications are made at a shallow depth between February and November, the limit is 47,500 pounds.

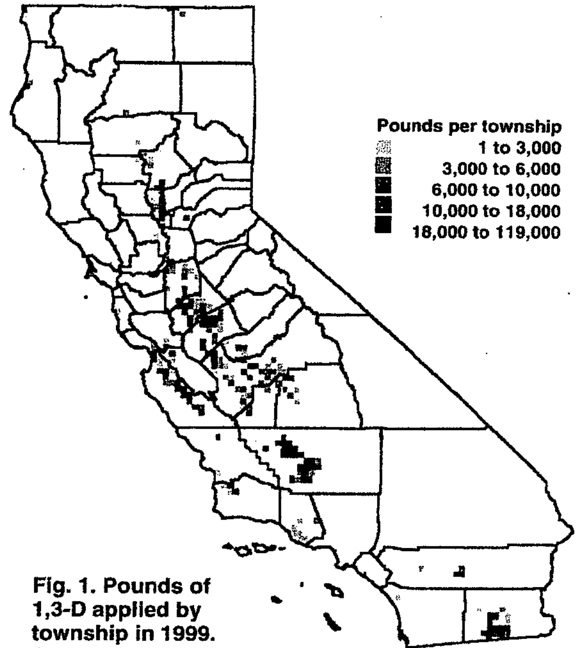

Fig. 1. Pounds of 1,3-D applied by township in 1999. Source: California Department of Pesticide Regulation.

In addition to the township caps, growers must maintain a buffer of 300 feet around occupied structures, which may be greater than that required for methyl bromide–treated acres. Growers must also meet soil-moisture requirements that may reduce the efficacy of 1,3-D. The liquid 1,3-D rapidly volatilizes into a gas when injected into the soil. The amount of soil moisture influences how well 1,3-D moves through the soil. If soil moisture levels are too high, efficacy can be reduced (Carpenter et al. 2000). Also, the maxi-

TABLE 1. Application rate assumptions used in 1,3-D township restriction analysis

Crop	1,3-D rate	Application depth
	lb/acre	
Almonds	332	>18"
Carrots	97.5	>18"
Grapes	332	>18"
Lettuce	76	<18"
Nursery	235	<18"
Peaches	332	>18"
Peppers	76	<18"
Strawberries	235	<18"
Sweet potatoes	190	>18"
Tomatoes	76	<18"
Walnuts	332	>18"
Watermelons	114	<18"

mum allowable application rate for 1,3-D is 24 gallons per acre for tarped fumigation and 35 gallons for untarped fumigation, which for some crops may not provide reliable pest control (Carpenter et al. 2000).

1,3-D demand estimates

The California pesticide use database provides detailed, spatial information on all pesticide applications, which allows calculation of pesticide use by township (CDPR 1999a). We use 1999 pesticide use data, the most recent available, to first compute current use of 1,3-D and methyl bromide in each township. We then estimate demand for 1,3-D after a methyl bromide phase-out for all methyl bromide–using crops for which researchers indicate that 1,3-D is the preferred alternative. Information was collected through two regional meetings, published research and numerous interviews with scientists, growers and policy-makers as to the relevant and most likely alternatives to methyl bromide following the ban (Carpenter et al. 2000). All current uses of 1,3-D are included in the calculation.

Growers who have depended on methyl bromide were assumed to switch to 1,3-D at application rates and depths appropriate to the practices specific to each crop (table 1). These assumptions are based on the opinion of a representative of TriCal, one of six companies authorized to distribute 1,3-D in California (personal communication, Kirk Fowler, TriCal general manager). While application dates are included in California's pesticide use database, they are not included in this analysis because growers can adjust treatment dates between February and November. Between 5% and 18% of 1,3-D applications are made during December and January. The impact of buffer zones required for 1,3-D, which may be larger than those required for methyl bromide, is also not considered due to the site-specific nature of those restrictions and the lack of information about the location of structures in relationship to treated fields. Inclusion of these variables would likely further limit the allowable 1,3-D treatment area.

TriCal

1,3-D is typically applied by custom applicators using a rig to inject the liquid into the soil, where it volatilizes into a gas.

1,3-D uses and restrictions

According to the U.S. Environmental Protection Agency (1998), 1,3-dichloropropene (1,3-D) is registered for use on soils to be planted with all food and feed crops. It can be applied only by certified applicators, and no home-owner uses are allowed.

1,3-D is highly volatile, and is mobile in soils; its persistence appears to be inversely related to temperature. 1,3-D is not believed to be a risk to birds or nontarget insects, but could be risky to aquatic invertebrates and fish, according to EPA.

1,3-D is classified as a category "B2" or "possible human carcinogen," by both oral and inhalation routes of exposure. In California, it is included on the Proposition 65 list of chemicals known to the state to cause cancer.

In 1986, EPA placed 1,3-D under special review, based on cancer concerns for workers, possible groundwater contamination and residues on crops grown in treated soils. In 1991, EPA's review was expanded to include inhalation exposures to residents who live near treated fields.

In 1992 and 1996, Dow AgroSciences requested new label changes to reduce levels of pesticide volatilization, including shut-off valves, closed loading, soil sealing, a 300-foot no treatment buffer from occupied structures, improved product stewardship, and reduced application rates. Additional restrictions and regulations apply in California (see p. 13).

In 1998, EPA published its reregistration eligibility decision (RED) for 1,3-D. "The agency has concluded that when labeled and used as specified, [1,3-D] will not cause unreasonable risks to human health or the environment," EPA wrote.

As a condition of reregistration, Dow AgroSciences agreed to conduct tap-water monitoring studies, and develop additional data on 1,3-D degradates, impacts on estuarine environments, and possible surface-water contamination. *–Editor*

U.S. Environmental Protection Agency. 1998. Reregistration Eligibility Decision: 1,3-Dichloropropene. Office of Prevention, Pesticides and Toxic Substances. EPA 738-R-98-016. www.epa.gov/oppsrrd1/REDs/0328red.pdf

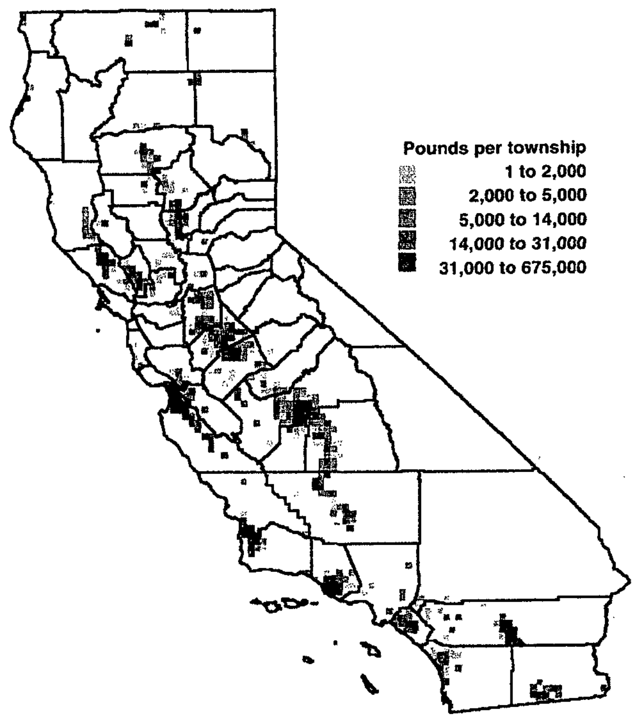

Fig. 2. Pounds of methyl bromide applied by township in 1999. Source: California Department of Pesticide Regulation.

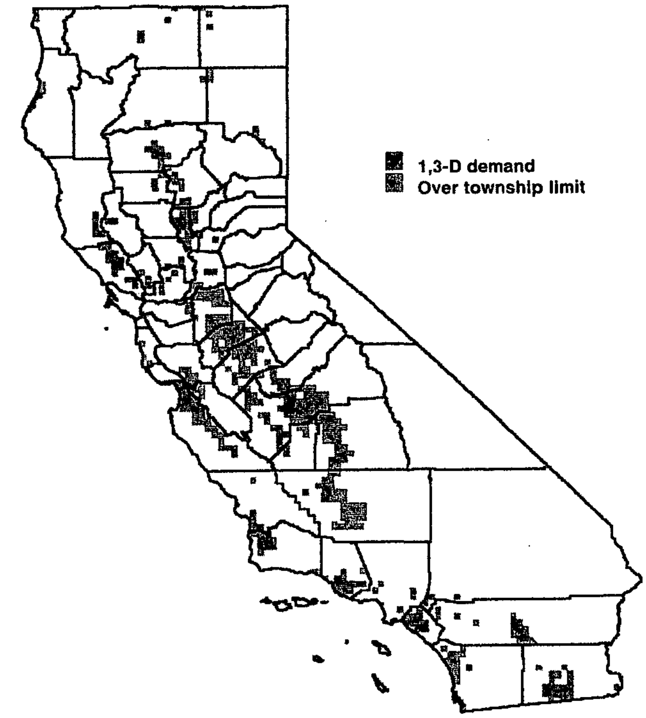

Fig. 3. Townships in which 1,3-D demand is expected to exceed regulatory limits.

Researchers identified the crops that are likely to use 1,3-D after the methyl bromide phase-out as strawberries, perennials, sweet potatoes, watermelons, peppers, tomatoes, carrots and lettuce, along with crops grown in nurseries (Carpenter et al. 2000; Methyl Bromide Alternatives 2000). Acreage in these crops represents over 90% of areas treated with methyl bromide. The remaining area that is treated with methyl bromide consists of other crops for which the likely alternative is not known.

Strawberries. Strawberries account for the single largest use of methyl bromide in California. Between 1997 and 1999, over 95% of the state's strawberry acreage was treated with methyl bromide. While a 50% methyl bromide phase-out went into effect in 2001, pesticide use data for 2000 and 2001 are not yet available. Areas that are not treated are either in organic production or are plantings in their second year of production. A great deal of research has been conducted to identify effective alternatives to methyl bromide for California strawberry growers (Methyl Bromide Alternatives 2000).

Researchers believe that after a methyl bromide phase-out, strawberry growers are likely to choose an alternative fumigant such as 1,3-D, chloropicrin, metam sodium or dazomet, most likely used in combination (Shaw and Larson 1999).

In Carpenter et al. (2000), we reviewed research into numerous chemical and nonchemical methyl bromide alternatives for strawberries (including solarization, organic cultivation and others), and determined that the no-fumigation option results in a 40% to 60% yield decrease. Although 1,3-D is not considered as cost-effective as methyl bromide, we believe growers will prefer it to not fumigating at all. Nonetheless, it remains unclear whether 1,3-D is an effective component of an alternative chemical treatment. In light of this uncertainly, we have analyzed two scenarios, assuming growers will or will not switch to 1,3-D.

Data adjustments. The 1999 pesticide use data were adjusted in order to address issues in the reporting of methyl bromide use. First, treated acreage may be overstated for methyl bromide applications in perennial crops due to reporting of spot treatments on less than 1 acre as full-acre treatments. Therefore, all records with application rates of less than 50 pounds per acre were deleted. Second, an adjustment was made for unspecified methyl bromide use. More than 2 million pounds of methyl bromide use is not reported as targeting any particular crop, accounting for more than 8,000 treated acres equal to 13% of areas treated with methyl bromide. Agricultural commissioners in the counties with a large amount of unspecified use were surveyed for further information on which crops were being fumigated. Unspecified use in Orange County (333,282 pounds) was assumed to be strawberry acreage. The breakdown of unspecified uses in Fresno, Madera and Tulare counties, which together account for more than 1.5 million pounds of unspecified methyl bromide use, is attributed to perennial crops. All 56,375 pounds of unspecified use in Siskiyou County was assumed to be for strawberry nurseries. Unspecified use in other counties is not included. Finally, 315 records of methyl bromide and 1,3-D

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Carrots are among the crops with the highest anticipated demand for 1,3-D after the methyl bromide phase-out.

TABLE 2. Estimated 1,3-D demand after methyl bromide phase-out*

County	With strawberries	Without strawberries
	lb	*lb*
Monterey	2,599,451	747,904
Ventura	2,152,026	188,289
Fresno	1,272,901	1,267,907
Merced	1,193,100	1,175,863
Kern	1,162,733	1,161,088
Santa Barbara	1,086,176	199,920
Tulare	762,886	762,886
Stanislaus	698,719	691,906
Santa Cruz	620,688	74,313
Orange	500,285	54,824
Riverside	400,625	398,111
San Joaquin	389,400	386,580
Sonoma	371,950	371,198
Imperial	356,378	356,378
Sutter	328,361	327,186
San Diego	211,062	175,083
San Luis Obispo	194,684	64,048
Butte	183,668	183,668
Madera	145,107	143,908
Lassen	125,340	0
State Total†	15,632,630	9,443,428

*Based on 1999 California pesticide use database.
†*Sum does not equal total. Not all counties shown.*

applications were identified as duplicates and deleted.

Impact of township restrictions

Binding township restrictions limit the number of acres that may be treated with 1,3-D in some areas. In 1999, two townships in Monterey County were over the 90,250-pound township limit. These totals are not adjusted to account for shallow application depth, which would lower the allowable amount of 1,3-D in each township to below 90,250 pounds. Eight other townships used more than 47,500 pounds of 1,3-D, which is the lower limit if all applications are made at a shallow depth from February to November. Three of these townships are in Kern County, where carrot acreage is concentrated. Fresno, Merced and Stanislaus counties each had townships exceeding 47,500 pounds of 1,3-D applications in 1999.

California growers applied a total of 14 million pounds of methyl bromide in 1999 on a wide variety of crops, including strawberries, tomatoes, flowers, perennials and nursery crops (fig. 2). If all these growers switch to 1,3-D after the methyl bromide phase-out, the restrictions are expected to limit 1,3-D use in even more townships.

With and without strawberries

Demand for 1,3-D is estimated to increase from 3 million pounds in 1999 to nearly 16 million pounds if strawberry growers use 1,3-D. However, under current restrictions, use would be limited to 10 million pounds, which is 64% of total demand (table 2). Monterey County is expected to have the highest demand for 1,3-D, primarily by strawberry growers, followed by Ventura County, also a major strawberry-producing county. Several of the other counties with high levels of demand are in the Central Valley: Fresno, Merced and Kern.

Demand for 1,3-D is estimated to increase to 9.4 million pounds if strawberry growers do not use 1,3-D (table 2). However, under current restrictions, use will be limited to 8.3 million pounds (88% of total demand). The level of demand is much lower in Monterey, Ventura, Santa Barbara, Santa Cruz and Orange counties if strawberry growers choose to use an alternative other than 1,3-D.

We predict that the restrictions will be binding in 47 townships (table 3; fig. 3). With the largest acreage in strawberry production, Monterey County has the most townships (10) with demand in excess of current limits. If strawberries are not included, the restrictions will be binding in 23 townships. Merced County has the highest number of townships (4) with 1,3-D demand over the limit, for treatment of sweet potatoes, almonds, peaches and nursery crops.

Distribution issues

The use of 1,3-D must be distributed by some mechanism in areas where the restrictions will be binding. Assuming the available 1,3-D is distributed by crop in proportion to its demand within each township, an estimate of which crops are most affected by the restrictions may be obtained. Along with nurseries, the crops expected to be most affected are strawberries, sweet potatoes, perennials, peppers, broccoli, and processing tomatoes (table 4).

For many crops, whether or not strawberry growers choose to use 1,3-D has little impact on how the restrictions will affect the amount of acreage that they are allowed to treat, since these crops are generally grown in areas where strawberries are not grown. This is the case for crops such as perennials, sweet potatoes, carrots and watermelons grown primarily in California's interior valleys. However, some crops would be in direct competition with strawberries for allotted 1,3-D use. These crops are grown in proximity to strawberries, including broccoli, Brussels sprouts, lettuce, peppers and tomatoes.

The pest control industry is charged with allocating limited 1,3-D use, reporting treatments made to county commissioners. To date, no entity has determined which crops or growers will be able to use 1,3-D and which will not. Several distribution mechanisms could be used to allocate pesticide use: first come, first served; quotas by crop, based on current or historical use; marketable permits; or a system based on the potential exposure of nearby populated areas. Currently, the use of 1,3-D is distributed on a first come, first served basis, as growers file notices of intent with the county agricultural commissioner just prior to treatment. Different methods will impact the distribution of benefits and costs under current regulations. Allowing the pest control industry to allocate distribution of limited 1,3-D use may not maximize society's welfare and may result in larger losses for the agricultural community after the phase-out of methyl bromide.

Qualifications of analysis

This analysis assumes that the production of crops will not geographically relocate following the phase-out due to restrictions on 1,3-D use. Yet some growers may be able to shift crop production to another township where the limits are not binding. Assuming growers are planting in the most profitable areas for both soil conditions and climate, shifting to another township may decrease profits. In other cases, production cannot shift in the short run, either because growers own the land they farm, the restrictions in nearby townships are already binding or no other region supplies the needed growing conditions. Some growers are likely to adapt to the restrictions by switching to crops that may be grown profitably without the use of 1,3-D.

In addition, new application methods, which decrease 1,3-D emissions, may allow the easing of the restrictions in California. Application of 1,3-D through drip irrigation systems, for instance, may reduce emissions from treated fields and allow larger areas to be treated. An emulsified version of Telone C-35 (1,3-D plus chloropicrin) recently received a full federal registration. Methods to reduce emissions during 1,3-D application for perennial crops are also being investi-

TABLE 3. Counties where 1,3-D township restrictions are expected to be binding*

	With strawberries		Without strawberries	
County	Number of townships over limit	Pounds of 1,3-D over limit†	Number of townships over limit	Pounds of 1,3-D over limit†
Del Norte	1	18,928	1	18,928
Fresno	3	113,297	3	113,297
Kern	3	408,242	3	407,349
Merced	4	464,758	4	442,589
Monterey	10	2,945,056	3	166,038
Orange	3	492,163	0	0
Riverside	3	97,793	3	97,793
San Joaquin	1	56,731	1	56,731
San Luis Obispo	1	6,961	0	0
Santa Barbara	4	1,332,752	0	0
Santa Cruz	4	702,404	0	0
Sutter	1	86,163	1	86,163
Tulare	3	90,087	3	90,087
Ventura	6	3,352,243	1	20,721
State total	**47**	**10,166,617**	**23**	**1,499,697**

*Based on 1999 California pesticide use database.
†Adjusted pounds where pounds of 1,3-D applied to a depth of less than 18 inches is counted as 1.9 pounds.

TABLE 4. Estimated acreage over township limit after methyl bromide phase-out

Crop	Acres over limit with strawberries	Acres over limit without strawberries	Total acres with 1,3-D demand
Almonds	230	226	2,159
Broccoli	924	626	1,600
Brussels sprouts	207	0	357
Carrots	296	286	8,824
Grapes	200	152	1,205
Lettuce	157	41	1,435
Nurseries	2,077	1,274	6,502
Peaches	173	173	1,401
Peppers	994	324	3,555
Soil application*	460	460	5,867
Strawberries	18,023	0	26,334†
Sweet potatoes	1,787	1,741	4,133
Tomatoes	772	471	6,625
Watermelons	187	186	2,001
State total‡	26,879	6,266	83,340

*Reported unspecified as to crop. The areas over the township limits are located primarily in Fresno and Tulare counties and are assumed to be perennial crops.
†Assuming strawberry growers choose to use 1,3-D. Two acres of strawberries were treated with 1,3-D in 1999.
‡Sum does not equal state total. Not all crops shown.

John Slumbos

◀ **A 50% reduction in methyl bromide went into effect on Jan. 1, 2001, based on 1991 usage levels. A wide range of alternatives will be needed for effective pest control in strawberries and other crops.**

gated. To the extent that current restrictions may be eased through the use of new application technologies, the impacts calculated here will overestimate how binding the restrictions will be. However, it is not yet known whether these methods will reduce emissions (personal communication, Ron Oshima, CDPR, Assistant Director of Scientific Affairs).

Finally, this analysis includes only 90% of current methyl bromide–treated areas. To the extent that any of the remaining 10% of methyl bromide–treated areas switch to 1,3-D after the phase-out, our analysis underestimates the impact of township restrictions.

Alternative strategies needed

The phase-out of methyl bromide is underway, requiring a 50% reduction from 1991 levels for 2001 calendar year. California is also in the process of implementing new regulations on methyl bromide to restrict its use in some areas for air quality concerns. As methyl bromide applications are restricted, policy analysts expect growers to switch to 1,3-D. The results of this analysis demonstrate the impact that limits on 1,3-D use in California will have after the phase-out of methyl bromide under current restrictions and application methods. Our findings indicate that areas where strawberries and perennial crops are grown will be most affected. The efficacy of 1,3-D applications with emissions-reducing techniques such as drip application and specialized tarps may allow larger areas to be treated than estimated here. Estimates of which specific crops will be affected depend on assumptions about the manner in which the 1,3-D use will be distributed, the possibility of relocating crop production and the availability of application methods to reduce emissions.

These results may also be used to guide research efforts into promising alternatives to both methyl bromide and 1,3-D, such as pesticide application techniques, new pesticides, herbicides and nonchemical pest control methods. Alternative pest control strategies must be developed and tested if 1,3-D cannot be applied to al acreage. Research to identify and develop alternatives to methyl bromide has included several alternatives, 1,3-D among them. While 1,3-D is considered the most effective alterna tive, our results underscore the importance of developing a wider rang of alternative practices.

J. Carpenter is Research Associate, National Center for Food and Agricultural Policy (NCFAP); L. Lynch is Assistant Professor, Agricultural and Resource Economics, University of Maryland, Co lege Park; and T. Trout is Agricultural Engineer, USDA Agricultural Researcl Service. *Lynch studied methyl bromide-related issues as part of doctoral researc at UC Berkeley. This study evolved fror the study funded by the USDA Econom Research Service, "The Economic Impa of the Scheduled Phase-out of Methyl Bromide in the U.S.," conducted by NCFAP, a Washington, D.C.–based think tank.*

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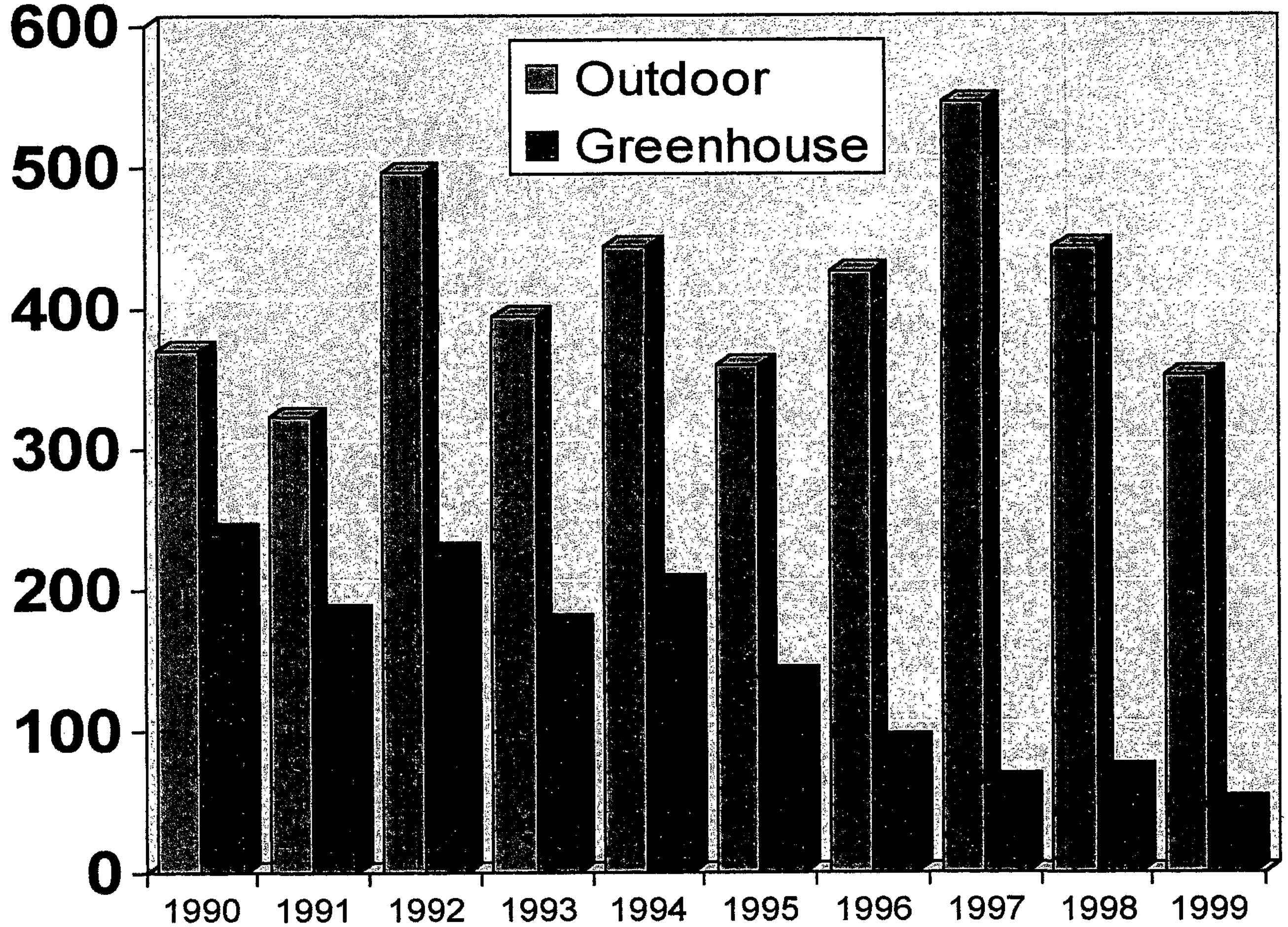
Pounds (in thousands) of methyl bromide used from 1990 through 1999



Alternatives for methyl bromide in field-grown cut flowers

Clyde L. Elmore and J. Roncoroni
University of California, Davis, CA

Field Studies-UC Davis: 2001

Study 1:

A field study was initiated at the University of California, Davis CA in a Yolo fine sandy loam soil (OM 1.08, sand 40%, silt 42%, clay 18%, pH 7.1). The 60 inch beds were preirrigated to reach field capacity by laying three driplines equidistance on the bed top. The bed was covered with a 1.1 mil clear polyethylene tarp. The acetic acid was applied on August 30, 2001 through the drip line at 1.0 and 2.5% in 380 mm of irrigation water. The tarps were maintained on the beds for 1 week. Soil moisture in the beds ranged from 50 to 79% moisture at the 15 cm depth. After the tarp was removed soil samples (10 cores, 15 cm deep of 2cm diameter) were taken under the driplines, between driplines and 30 cm from the dripline composited from each site per plot and analyzed separately for soil pH.
Transplant speedlings of the cut-flower species, column stock (*Matthiola incana*), godetia (*Clarkia amoena*), and snapdragon (*Antirrhinum majus*) were planted at 7, 14 and 21 days after the tarp was removed.
Weed evaluations and ornamental vigor were made on October 9, and November 18, 2001.

Study 2.

A field study was initiated on the extension of the beds at a same site as study 1. The soil moisture was not at field capacity as in the previous study. Satchets of the pest organisms, field bindweed and yellow nutsedge tubers was buried at 5, 15 and 30 cm depth in each plot under the center drip line. Treatments of 1.0%, 1.5% or 2% acetic acid, sodium azide at 67 or 112 kg/ha and metam sodium at 348 kg/ha were applied October 25, 2001 through the drip lines using 380 mm water. The tarp was removed after one week and weed control was evaluated November 20, 2001. The satchets were removed at one week after treatment and sprouted in the laboratory.

Weed seed was placed onto 1 layer of Whatman filter paper in petri dishes and placed into a germinator at 28/18 day/night temperature for two weeks where germination was counted and seedlings were removed. After this time, a squeeze test was determined to test viability (hard seed was determined to be viable with a 1% tetrazolium test).

Results:

Study 1:

In this plant drip applied study sodium azide at 67.2 or 112 kg/ha controlled henbit, rough pigweed, common purslane, and annual bluegrass and was equal to 358 kg/ha of metam dripped into the beds. This test on a sandy clay loam soil gave control across the full bed. Furfural/AITC at 6% AITC did not the equivalent control as metam however except for common purslane was acceptable. The combination at a 20% AITC concentration improved weed control of most weeds (Table 1).
In plant-back studies using herbaceous ornamental cut flower speedlings, snapdragon and Godetia transplant vigor was reduced early in the season with sodium azide at 112 kg/ha compared to the untreated plants (Figure 1,2,3 and Table 2). All plant growth was increased with a treatment of metam compared to the control.

Study 2.

In this second field drip irrigation applied study, metam at 358 kg/ha and sodium azide at 67 or 112 kg/ha controlled almost all weeds present including wild mustard, annual bluegrass, common chickweed and dead nettle (Table). Metam sodium and the sodium azide at 112 kg/ha controlled red maids (*Calandrinia ciliata*) but less control was obtained with 67 kg/ha.
Acetic acid gave more control than a water treated control, however, except for the 2.5% it was not as effective as metam sodium or sodium azide. These results vary from the first field study in that less control was achieved. This was probably due to the reduced moisture in the bed before application of the chemicals were begun. The reduced moisture allowed the chemical to adhere to the drier soil and not move across the bed. Control was evident under the drip lines.
Yellow nutsedge shoot emergence was only reduced with metam sodium at 358 kg/ha (Table). Tuber viability was reduced with metam. Though the tubers did not emerge, a few were still viable after treatment. Dead tubers were highest at 81% in the metam sodium treatment (Table). Other treatments killed a similar number of tubers though acetic acid at 2.5% concentration reduced them by 31%.

Field Study 3:

Carlsbad, Preplant drip application of fumigants:

Drip applied trial- The predominant resident weed, clover, was greatly reduced with all treatments after drip application. Common sowthistle, malva and wartcress were also reduced compared to the untreated water control plots.
From satchets, seeds of annual bluegrass and common purslane were exhumed after placement at 7,15 and 30 cm depth in the beds before treatment. Metam at 358 kg/ha and iodomethane/chloropicrin at 392 kg/ha (50:50%) gave almost complete control of annual bluegrass and was similar to each other through the drip system. Iodomethane/chloropicrin gave better control of common purslane than metam. Chlorpicrin at 224 or 336 kg/ha also gave significant control and 336 kg/ha was numerically higher than 224 kg/ha. Sodium azide at 67.2 kg/ha gave some control of annual bluegrass and common purslane but was not as good as 112 kg/ha. The sodium azide gave better control of purslane at the 15 cm depth than either the 7 or the 30 cm depths. This would indicate that there is some water related movement versus control concern in light sandy soils where it moves out of the surface of the soil. This needs to be evaluated more thoroughly in different soil types and different amounts of water. The combination of 1,3-D and chloropicrin gave excellent control of annual bluegrass and common purslane in this study.

These trials will be repeated in spring of 2002.

Table 1. Preplant weed control from drip applied herbicides –Study 1-UC Davis-2001

Treatment	Rate (kg/ha)	henbit*	rough pigweed	common purslane	annual bluegrass	All weeds
Na azide	67.2	9.8 ab	9.8 a	10.0 a	9.7 a	9.0 a
Na azide	112	10.0 a	9.7 a	9.8 a	10.0 a	9.3 a
Furfural/AITC	448 (6% AITC)	8.3 b	7.5 b	6.0 c	10.0 a	7.0 b
Furfural/AITC	448 (20%AITC)	9.5 ab	8.7 ab	8.0 b	9.7 a	8.0 ab
Metam	358	10.0 a	10.0 a	9.5 a	10.0 a	8.8 a
Control	------	2.0 c	3.3 c	2.3 ab	5.3 b	4.0 c
LSD 0.05	------	1.641	2.127	1.747	2.043	1.59

*

Table 2. Plant-back tolerance of three herbaceous annual flowers to preplant herbicides–Study 1-UC Davis-2001

Treatment	Rate (kg/ha)	Column Stock		Snapdragon		Godetia	
		10-9	11-18	10-9	11-18	10-9	11-18
Na azide	67.2	8.4 a	9.4 a	7.9 ab	8.6	8.3 b	8.3
Na azide	112	8.3 a	9.3 a	6.9 c	7.7	7.0 c	7.1
Furfural/AITC	448 (6% AITC)	8.4 a	7.9 b	7.6 b	7.1	9.2 a	8.7
Furfural/AITC	448 (20%AITC)	8.4 a	8.0 b	7.9 ab	8.1	8.7 ab	8.4
Metam	358	8.6 a	8.9 ab	8.3 a	8.9	9.0 a	9.3
Control	------	7.4 b	6.8 c	7.2 bc	7.1	8.1 b	7.7
LSD 0.05	------	0.820	1.079	0.412	NS	0.667	NS
Probability		0.034	0.0019	0.021	0.0708	0.019	0.052

*

Table 3. Control of annual weeds within 6 inches of a drip-line applied preplant herbicide.

Treatment	Rate (Kg/ha)	wild mustard*	annual bluegrass	red maids	common chickweed	common purslane	dead nettle
Metam sodium	358	10.0 a**	10.0 a	9.0 a	9.5 a	10.0 a	10.0 a
Sodium azide	67	10.0 a	10.0 a	7.2 bc	9.0 a	10.0 a	10.0 a
Sodium azide	112	10.0 a	10.0 a	8.9 ab	10.0 a	10.0 a	10.0 a
Acetic acid	1.0%	2.5 d	3.2 c	5.2 d	3.2 c	4.2 c	3.0 c
Acetic acid	1.5%	5.2 c	5.8 b	7.0 c	5.2 b	7.0 b	5.8 b
Acetic acid	2.5%	7.9 b	6.8 b	8.6 abc	6.0 b	6.8 b	7.0 b
Water treated control	-----	0.0 e	0.0 d	0.0 e	0.0 d	0.0 d	0.0 d
LSD P = 0.05	-----	1.003	1.115	1.731	1.088	0.9407	1.259

*Weed Control: 0 = no control; 10 = complete control

** Means in columns separated by Fischers protected LSD P = 0.05.

Table 4. Preplant control of yellow nutsedge after drip application of soil herbicides in the field.

Treatment	Rate	Emergence*	viability**	dead (%)
Metam sodium	358 kg/ha	0.0 b	1.3 c	81.1 a
Sodium azide	67.2 kg/ha	4.4 a	6.0 ab	16.0 c
Sodium azide	112 kg/ha	4.5 a	6.0 ab	17.1 bc
Acetic acid	1%	5.2 a	6.4 a	12.5 c
Acetic acid	1.5%	4.4 a	6.5 a	12.2 c
Acetic acid	2.5%	3.9 a	4.9 b	31.0 c
Water treated control	-----	4.9 a	6.3 a	10.0 c
LSD (at P = 0.05)	-----	1.475	1.116	14.86

* Number of emerged shoots from eight nutlets planted

** Number of viable nutlets (includes the nutlets that sprouted)

Table 5.Weed control and affect on Ranunculus germination from preplant drip applied fumigants – Carlsbad, California

		Clover		Sow thistle		Malva		Wartcress		Ranunculus
Treatment	Rate (lb/A)	1/11/02*	1/22/02*	1/11/02	1/22/02	1/11/02	1/22/02	1/11/02	1/22/02	1/22/02
Metam sodium	320	0.0 b	18.2 bc	0.0 b	0.0	0.2 b	0.4	0.0	0.0	41.8
Iodomethane/chlorpicrin	350 (50:50)	0.9 b	29.2 a	0.0 b	0.0	0.0 b	0.0	0.0	0.0	46.0
Chloropicrin	200	0.5 b	24.4 ab	0.0 b	0.0	0.3 b	0.2	1.2	0.6	46.0
Chloropicrin	300	0.1 b	17.0 bc	0.0 b	0.0	0.4 b	0.2	0.0	0.4	56.2
Sodium Azide	60	0.0 b	28.0 a	0.0 b	0.4	0.0 b	0.2	0.0	1.6	45.2
Sodium Azide	100	0.0 b	17.0 bc	0.0 b	0.2	0.0 b	0.0	0.0	0.4	47.0
1,3-D + chloropicrin	150 +150	0.0 b	21.6 abc	0.0 b	0.0	0.0 b	0.2	0.0	0.0	41.4
Untreated - water	------	39.1 a	12.4 c	2.8 a	0.2	1.9 a	0.2	4.4	0.4	41.8
LSD 0.05	------	6.002	9.485**	0.8662	NS	0.8059	NS	NS	NS	NS
Probability	------	0.0000	0.0627	0.0000		0.0005		0.3806	0.2429	

* Evaluated using a 1 foot by 4 feet quadrat on the bedtop on 1/11/02 and a 2.5 feet by 2.0 feet on the bedtop on 1/22/02
Note: The control plots were rough hand weeded between the first and second evaluation rendering the lack of significance between treatments and the untreated plots.
** Analyzed at P = 0.10

Clyde Elmore, University of California, Davis
May, 2002

Preliminary comments on studies:

Field replicated trials

Carlsbad, CA.-Ranunculus

Black mustard seeded in the plots was controlled with all treatments. Though there appeared that iodomethane + chloropicrin at 350 lb/A reduced clover, the reduction was not significantly different. Iodomethane seemed to control *Malva parviflora* better than methyl bromide/chloropicrin in this trial. Malva was suppressed with all treatments in the wet trial at his site whereas clover was not affected significantly by treatment.
Initial Ranunculus stand counts did not show any differences between treatments.
The first harvest did not show any differences between treatments either in the methyl bromide/chloropicrin and iodomethane comparisons or the metam and Dazomet comparisons.
During the harvest season, there was a pronounced reduction in vigor in the untreated plots compared to methyl bromide/chloropicrin treatment or the iodomethane/chloropicrin treatments.

Santa Maria, CA-Gladiolus

Gladiolus bulbs were planted back into the iodomethane plots 9/4/01 (8 days after treatment and two days after the tarp was removed), 9/11/01, 9/18/01 and 9/25/01. When growth evaluations were analyzed there was no difference between dates of planting in the methyl bromide and iodomethane treatments. Several different varieties were planted and though there was difference between varieties they were not replicated between treatments and could not be analyzed. Within variety, S19-14 gladiolus growth was improved with any fumigation treatment. Iodomethane/chloropicrin increased growth of both S359 and HY gladiolus varieties over the control or methyl bromide/chloropicrin in this study.
Cormlet number was reduced with methyl bromide/chloropicrin or the iodomethane/chloropicrin combinations compared to the control and there was no differences between treatments.
In the metam or dazomet combination study, excellent weed control was apparent with all treatments compared to the control and gladiolus vigor was exceptional. All treatments gave gladioli cormlet control compared to the untreated plots.

Santa Cruz, CA- Calla Lily

Black mustard that had been planted was reduced with all preplant treatments compared to the control. Control was only about 75% however compared to the control. Calla lily bulb vigor was not affected by any treatment when evaluated as large size plants per treatment. Residual *Zantedeschia childsiania* tubers in the soil were controlled with methyl bromide/chlorpicrin and the two iodomethane/chloropicrin treatments. The trial area was treated with linuron thus no additional weed control evaluations could be taken.
The number of open flowers of Calla was reduced with iodomethane when evaluated on April 18, 2002 though the vigor was not reduced compared to methyl bromide/chloropicrin. Plant vigor was reduced in the untreated control compared to all treatments except metam + C-35.

Ano Nuevo, CA-Calla, Delphinium, Column stock.

Weed control was excellent with either methyl bromide + chloropicrin at 350 lb/A or with iodomethane plus chloropicrin at 300 or 350 lb/A. These were not significantly different from each other for any weed species. Delphinium transplants were more vigorous planted into methyl bromide/chloropicrin than either iodomethane /choropicrin treatments. Plants in all treated areas were more vigorous than the control plants.

Weed control in the metam or dazomet combination treatments was similar to methyl bromide with metam+ C-35 or with dazomet + C-35.The two treatments gave better weed control than metam alone or in combination with the other combinations of 1,3-D and chloropicrin. Metam incorporated but untarped was not as effective for weed control as in tarped plots. Yield of stock was highest in a combination of Dazomet and C-35. With most weed species and with total weed numbers, all treatments reduced weed numbers compared to the untreated plots.
Column stock (direct seeded) seemed to be least affected by a preplant treatment of dazomet + C-35 in this study. Calla lily vigor was lowest after treatment with metam tarped without 1,3-D or chloropicrin, though the number of shoots were not reduced significantly with any treatment. Vigor of Delphinium species did not seem affected by any preplant treatments.
Without weed control (except one weeding in the row to take cost of weeding data) no yield was produced in untreated plots with Delphinium or stock. There were more flower stems to harvest in the last evaluation in methyl bromide treated plots compared to iodomethane/chloropicrin at either 300 or 350 lb/A.
Additional data will be taken on each of the preplant fumigation studies.

Carlsbad, Preplant drip application of fumigants:

Drip applied trial- The predominant resident weed, clover, was greatly reduced with all treatments after drip application. Common sowthistle, malva and wartcress were also reduced compared to the untreated water control plots.
From satchets, seeds of annual bluegrass and common purslane were exhumed after placement at 7,15 and 30 cm depth in the beds before treatment. Metam at 320 lb/A and iodomethane/chloropicrin at 350 lb/A (50:50%) gave almost complete control of annual bluegrass and was similar to each other through the drip system. Iodomethane/chloropicrin gave better control of common purslane than metam. Chlorpicrin at 200 or 300 lb/A also gave significant control and 300 lb/A was numerically higher than 200 lb/A. Sodium azide at 60 lb/A gave some control of annual bluegrass and common purslane but was not as good as 100 lb/A. The sodium azide gave better control of purslane at the 15 cm depth than either the 7 or the 30 cm depths. This would indicate that there is some water related movement versus control concern in light sandy soils where it moves out of the surface of the soil. This needs to be evaluated more thoroughly in different soil types and different amounts of water. The combination of 1,3-D and chloropicrin (Inline) gave excellent control of annual bluegrass and common purslane in this study.
After 20 weeks from application Ranunculus vigor was greater in the sodium azide treatment at 60 lb/A compared to iodomethane/chloropicrin at 350 lb/A, Inline, or the control plants. Other treatments were not different and by 25 weeks after treatment, there were no differences in vigor.

There was no difference between treatments in the number of bunches harvested at the first harvest.

Preplant drip applied fumigants- Study 1: Davis, CA

All treatments (sodium azide 60 and 100 lb/A, furfural/AITC 400 lb (6% AITC) and furfural/AITC at 400lb (20% AITC) and metam at 320 lb/A gave better than 75 % control of all annual weeds in this sandy loam soil. Furfural/AITC with 20% AITC gave better common purslane control than the lower AITC concentration. Three drip lines per 60 inch bed was adequate to distribute the materials across the bed top. Weeds controlled included dead nettle, pigweed, common purslane and annual bluegrass. Transplant of column stock, snapdragon and Godetia were planted at three intervals into the treatments after the tarps were removed. Stock plants were more vigorous in all treated plots than the controls. Snapdragon growth was reduced in the first planting (17 days after application) with the 100 lb/A rate of sodium azide, but not in later plantings.

Preplant drip applied fumigants- Study 2: Davis, CA

Drip applications of metam (320 lb/A) or sodium azide (60 or 100 lb/A) controlled annual weeds in this trial in a sandy loam soil. Acetic acid concentrations of 1.0 or 1.5% was not adequate to control most weeds but the control under the drip line was excellent (the material did not move across the bed even with 3 drip lines per 60inch bed. A concentration of 2.5 % did give control at the 70 to.86% range on different weed species.
These trials will be repeated in spring of 2002.

Education Programs:

Four growers representing different areas of the state and growing conditions have cooperated in these studies. Farm Advisors in each of these counties are also cooperating with the studies. TriCal has cooperated extensively to apply chemicals in some of these trials. Also, other chemical company representatives from Nikor, Dow AgroSciences and Cal Agri have assisted with chemical and application experience.
A field demonstration day has been planned for two locations where these trials are located. In addition, a tour from the Society of Florists (SAF) will stop at one of the studies in February. A University of California farm advisor training session will be conducted in March of 2002. A story is being prepared on methyl bromide alternatives studies in California with American Nurseryman Magazine in February.

Preplant methyl bromide alternatives study – Ano Nuevo Flower Gardens
October 23, 2001

In field-grown flowers weeds are a major part of the pest control budget. In the absence of methyl bromide and without selective herbicides, weed control costs and difficulty of production will increase. There is likely a need for an increase in frequency and number of cultivations as well as an increase in hand labor. Combinations of preplant pesticides are being evaluated fro broad-spectrum pest control in field flowers, hoping to put together treatments that will give an effective alternative control method.

A site was selected in a clay soil at the Ano Nuevo Flower Gardens off of Highway 1 south of Pescadero, California. The field had not been farmed because of a broad spectrum of pests. The site was cultivated, sprinkler irrigated staked out for two trials, one in wet soil (about 40% moisture at 6 inches) and one in soil below field capacity (10-20% moisture). Field plots were 15 X 150 feet in the dry side with four replications in a randomized block design. In the wet side the plots were 17 X 150 feet with four replications. The studies were separated by about 200 feet so the moisture levels would be uniform throughout the studies.

Soil samples (12-3/4 inch cores were taken to 12 inches and composited) were taken from each plot before treatment. Samples were analyzed for soil pathogens and nematodes in the laboratory. A sample was submitted to the University of California, DANR laboratory for analysis of organic matter, sand, silt and clay percent.

The pesticide treatments listed below were applied by commercial applicators (Tri-Cal, Inc. Hollister, CA on October 23, 2001.

The following procedure was employed in the wet soil treatments:

1) metam 75 gal/A (320 lb/A) was applied with a blade and incorporated to 6 inches followed with a power roller. A mixture of 1,3-D plus chloropicrin (C-35) was applied by shanks to 18 inches depth by a second piece of equipment and was covered with a 1.1 mil polyethylene tarp.
2) Metam 75 gal/A (applied in the same manner as above) followed with the second piece of equipment with Telone II shanked at 18 inches (15 gal/A) and chloropicrin shanked at 18 inches (200 lb/A) and covered with a tarp.
3) Metam 75 gal/A (applied in the same manner as above) then tarped.
4) Dazomet was applied with a Scott drop spreader (200 lb/A) onto the soil surface and then followed with the Telone II and chloropicrin mixture (C-35) as in treatment one.
5) Dazomet was applied with a Scott drop spreader (200 lb/A) onto the soil surface and then followed with the Telone II and chloropicrin mixture as in treatment 3.
6) Metam 75 gal/A (applied as in treatment 1) but was not tarped.
7) Untreated control and tarped with the polyethylene tarp.

(These treatments are listed as treatments 5 through 11 in plot maps).

In the dry soil side treatments the following procedures were followed:

1) Methyl bromide/chloropicrin (50:50%) mixture was applied at 350 lb/A using shanks to 18 inches and immediately tarped.
2) Iodomethane/chloropicrin (50:50%) mixture was applied at 300 lb/A using shanks to 18 inches and immediately tarped.
3) Iodomethane/chloropicrin (50:50%) mixture was applied at 350 lb/A as in treatment 2.
4) Untreated control that was tarped.

After 7 days the tarps were cut and pulled 48 h later.
Beds were pulled in the center of each plot to be planted with Delphinium transplants or direct seeded, Calla tubers planted and stock seeded in each plot.

Weed evaluations and plant vigor or stand counts will be made during the season.

Preplant fumigation affect on newly planted field-grown flower crops – Ano Nuevo, CA.

Treatment	Rate	Stock**	Delph***	Delph***	Stock**	Delph**	Calla vig.	Calla No.	Calla vig	Calla No.	Delph***	Delph***
		12-10-01			1-9-02							
Metam + C-35*	320 + 35 gal	7.8 ab	8.0	8.5	5.0	4.0	7.5 ab	20.0	7.5	17.2	6.8	6.0
Metam + 1,3-D + Pic*	320 + 15 +	9.5 a	7.0	8.5	6.8	3.8	7.2 ab	30.8	7.2	24.8	5.0	5.5
Metam*	320 lb	7.2 ab	6.8	6.8	4.2	2.2	5.5 c	22.5	6.0	23.2	5.8	4.5
Dazomet +C-35*	200 + 35gal	9.8 a	8.0	7.5	6.0	3.5	7.8 a	27.2	7.2	22.8	5.2	4.0
Dazomet + 1,3-D + Pic*	200 + 15 +	6.9 b	7.2	8.2	4.8	4.0	7.0 ab	22.0	7.2	24.8	6.5	5.7
Metam	320	6.0 b	6.0	7.8	4.0	2.8	6.2 bc	18.0	6.0	27.0	6.0	5.5
Control	---	5.2 b	7.0	7.5	2.0	1.0	6.5 abc	14.8	6.0	15.8	5.5	5.8
LSD (P= 0.05)	---	2.602	NS	NS	NS	NS	1.323	NS	NS	NS	NS	NS
Probability	---	0.0141	0.0879	0.196	0.089	0.197	0.261	0.0661	0.2341	0.0841	-----	0.2968

* Treated area covered with a clear polyethylene tarp for one week

** Planted from seed

*** Planted from transplants

Means followed by the same letter are not significantly different as separated by Fischers LSD P = 0.05.

Weed Control from preplant fumigation in field-grown flower crops-Ano Nuevo-2001

Treatment	AnB	Oxalis	Mustard	B. clov	Chick	C. grou.	C. sowth	Corn sp	Bitter	Shep.	Total**	Total ***
Metam +C35*	0.8 c	0.0	0.0 c	0.25 b	0.25 b	0.25 b	0.0	0.0 b	0.25 b	0.0 b	0.0 b	1.8 b
Metam + 1,3-D + pic*	0.5 c	0.5	0.0 c	1.8 a	0.0 b	0.0 b	0.0	0.0 b	0.0 b	0.25 b	1.0 b	3.0 b
Metam *	8.5 bc	2.8	3.0 ab	0.0 b	8.5 ab	0.5 b	2.0	3.2 b	4.2 b	1.8 b	5.25 b	34.5 b
Dazomet + C35*	2.0 bc	0.0	0.0 c	0.25 b	1.2 b	0.25 b	1.2	0.0 b	0.25 b	0.0 b	0.5 b	5.2 b
Dazomet + 1,3-D + pic	6.5 bc	0.5	1.2 bc	0.8 b	4.8 b	0.5 b	0.0	0.5 b	1.8 b	0.25 b	5.8 b	16.8 b
Metam	26.5 ab	1.8	0.8 bc	0.2 b	6.5 b	0.0 b	0.0	1.8 b	2.8 b	0.0 b	17.0 b	40.2 b
Untreated*	49.2 a	2.8	4.5 a	1.5 a	19.5 a	5.5 a	5.0	12.2 a	18.0 a	5.25 a	74.2 a	123.5 a
LSD (P = .05)	25.43	NS	2.99	1.079	12.27	3.589	NS	7.969	7.514	3.353	25.71	44.91

* Covered with a polyethylene tarp for 1 week

** Total weeds from 12/10/01

*** Total weeds from 1/9/02

AnB = annual bluegrass, Oxalis = Oxalis pes capre, Mustard = Brassica nigra, B. clov. = California bur clover, Chick = common chickweed, C. grou. = common groundsel, C. sowth. = common sowthistle, Corn sp = corn spurry, Bitter = bittercress, Shep. = shepherd's spurse.

Table Weed control after preplant fumigation, Ano Nuevo, April 23, 2002

Treatment	Rate (lb/A)	Wortcress	Bur clover	Oxalis	Willowherb	Brassbuttons	Brist. oxtongue
MBr/pic	350 (50:50)	4.8	7.4	5.5	7.8	7.5	9.8
Iodo/pic	300 (50:50)	3.8	7.2	5.2	6.0	7.2	8.7
Iodo/pic	350 (50:50)	3.5	7.5	5.5	6.2	5.8	8.8
Untreated	----	1.2	1.5	1.5	2.2	0.8	0.8
LSD 0.05							
Probability	----						

Table Plant vigor and flower stalks of Delphinium belladonna, D. cultorum and Stock after preplant fumigation in the field.
April 23, 2002, Ano Nuevo.

Treatment	Rate	D. belladonna Vigor*	D. belladonna Flower Stalks**	D. cultorum Vigor*	D. cultorum Flower Stalks**	Calla vigor*	Stock Vigor*	Stock Flower Stalks**
Metam + C-35	320 + 35 gal	5.8	5.5	7.5	14.5	8.2	6.5	18.8
Metam + 1,3-D + pic	320 + 15 gal+ 200	5.5	5.25	7.5	16.2	8.0	5.5	22.8
Metam	320	2.8	1.8	2.5	1.0	4.0	2.0	2.5
Dazomet + C-35	200 + 35 gal	6.8	5.2	8.8	19.8	8.0	6.5	31.5
Dazomet + 1,3-D + pic	200 + 15g + 200	4.5	3.8	6.2	15.8	7.2	3.8	8.5
Metam***	320	0.8	0.0	1.0	0.0	4.0	1.0	0.5
Untreated	----	0.5	0.0	0.0	0.0	4.0	0.5	0.0
Probability	----							

* Vigor: 1 = dead, 5 = excellent vigor
** Flower stalks per plot
*** Metam incorporated and rolled but not tarped.

Table Plant vigor and flower stalks of Delphinium belladonna, D. cultorum and Stock after preplant fumigation in the field.
April 23, 2002, Ano Nuevo.

Treatment	Rate (lb/A)	D. belladonna Vigor*	D. belladonna Flower Stalks**	D. cultorum Vigor*	D. cultorum Flower Stalks**	Calla vigor*	Stock Vigor*	Stock Flower Stalks**
MBr/pic	350 (50:50)	6.75	10.25	4.5	9.25	7.25	3.0	0.5
Iodo/pic	300 (50:50)	5.25	7.25	3.25	5.25	6.5	3.8	2.5
Iodo/pic	350 (50:50)	3.5	2.0	3.5	5.5	6.5	3.5	3.2
Untreated	----	1.5	0.0	0.5	0.0	4.0	0.0	0.0
Probability	----							

* Vigor: 1 = dead, 5 = excellent vigor

** Flower stalks per plot

Table Gladioli vigor and growth by varieties and dead plants.

	Vigor*			Growth**			
	11/4/01	12/12/01	2/18/02	S19-14	S359	HY	HY***
Control	6.93	5.28	4.07	3.5 b	2.9 b	2.2 b	6.5 a
MeBr	7.92	8.31	5.73	5.0 a	3.2 b	2.4 b	5.5 a
Iodo/pic	6.83	7.66	4.54	5.0 a	2.9 b	3.2 a	1.5 a
Iodo/pic	6.44	7.04	4.31	4.96 a	4.1 a		
Probability							

* Vigorous = 10, 1 = dead

** Growth 5 = maximum growth

*** Dead plants from Fusarium

Table Gladioli vigor by variety as affected by planting time in Iodomethane/chloropicrin at 300 and 350 lb/A*.

	300 lb/A (50:50%)				350 lb/A (50:50)		
Planting time	HY	The Queen	Cranberry	Sophia	The Queen	Cranberry	Sophia
9/4/01	3.7 a	2.2 a	2.9 a	2.9 a	2.1 a	2.1 a	3.0 a
9/11/01	4.2 a	2.8 a	3.2 a	3.2 a	2.4 a	2.4 a	3.0 a
9.18.01	4.0 a	2.4 a	3.2 a	3.1 a	2.4 a	2.4 a	3.0 a
9/25/01	4.0 a	2.5 a	2.6 a	2.9 a	2.5 a	2.5 a	2.5 a

Gladioli vigor 5 = vigorous, 1 = dead

Note: Evaluations taken by Dr. Ann Chase and Clyde Elmore

Table Control of weeds in gladiolus with preplant fumigation-Santa Maria-2001/02

Treatment	Rate(lb/A)	Malva (No.)* 9/20/01	Malva vigor** 10/27	Malva (No.) 11/4	Cormlets (No.) 9/20	Cormlet control 10/27	Cormlet (No.) 11/4	Common groundsel 11/4	Common sowthistle 11/4
MBr/Pic	350 (50:50)	10.8	9.1 a	33.2	0.0	9.8 a	0.5 b	10.8	4.5
Iodomethane/chloropicrin	300 (50:50)	30.8	8.9 a	146.8	0.0	10.0 a	0.3 b	120.0	49.5
Iodomethane/chloropicrin	350 (50:50)	28.0	9.9 a	62.2	0.2	9.5 a	0.1 b	45.0	16.5
Untreated	-----	34.5	5.1 b	168.2	5.0	2.2 b	2.5 a	24.0	6.0
LSD 0.05	-----	NS	3.18	NS	NS	1.676	0.936	NS	NS
Probability	-----	0.4508	0.0321		0.178		0.0008	0.206	0.381

* Number per one row and two bed tops for 130 feet long

** Vigor-visual evaluation; 10 = vigorous, 0 = dead plants

Table Weed Control in preplant fumigated gladiolus – Santa Maria – 2001/02

Treatment	Rate (lb or gal/A)	Malva No. (9/20)*	Malva control (10/27)**	Malva No. (11/4)	Common groundsel(11/4)	Cormlet control (10/27)
Metam + C-35	320 lb + 35 gal	0.0	10.0	1.3	259.3	10.0
Metam + 1,3-D + chloropicrin	320 lb + 15 gal + 200 lb	2.7	10.0	0.3	86.0	10.0
Metam	320 lb	0.7	10.0	5.7	514.0	10.0
Dazomet + C-35	200 lb + 35 gal	0.3	10.0	0.0	107.8	9.5
Dazomet + 1,3-D + chloropicrin	200 lb + 15 gal + 200 lb	1.0	9.9	2.3	196.0	10.0
LSD 0.05	-------	NS	NS	NS	NS	NS
Probability	-------			0.825	0.097	

Table Preplant control of black mustard and volunteer Z. childsiania if field planted Calla lily-Golden State

Treatment	Rate	Black mustard control*	Volunteer control	Plant vigor***
Methyl bromide*	350(50:50)	20.3 b	21.5 b	8.5
Iodomethane/chloropicrin*	300 (50:50)	21.8 b	0.8 c	8.0
Iodomethane/chloropicrin*	350 (50:50)	11.3 b	0.2 c	8.5
Control*	------	45.9 a	69.5 a	8.5
Metam + C-35*	75 gal + 35 gal	NA	1.5 c	8.0
Metam + 1,3-D + chloropicrin*	75 gal + 15 + 200	NA	3.2 c	8.8
Dazomet + C-35*	200 lb + 35 gal	NA	0.5 c	8.5
Dazomet + 1,3-D + pic*	200 lb +15 + 200	NA	0.5 c	8.8
Metam sodium*	75 gal (320 lb)	NA	0.8 c	9.5
LSD 0.05	------	23.8	14.91	NS
Probability	------	0.0473	0.0000	0.8961

*Mean number per 4 ft2

** Number of large plants per plot (at least one full leaf expanded)

*** Plant vigor: visual where 10 = vigorous plant, 0 = dead

Table Preplant effect on calla vigor and open flowers and total weed control in field planted Calla lily-Golden State

Treatment	Rate	Calla (open flowers)*	Calla vigor**	Total weeds
Methyl bromide*	350(50:50)	52.6 cd	9.2 a	1.0 b
Iodomethane/chloropicrin*	300 (50:50)	48.9 d	9.0 a	3.2 ab
Iodomethane/chloropicrin*	350 (50:50)	50.4 d	8.8 a	2.5 b
Control*	------	57.4 bcd	7.2 b	7.0 a
Metam + C-35*	75 gal + 35 gal	70.9 abc	8.5 ab	0.2 b
Metam + 1,3-D + chloropicrin*	75 gal + 15 + 200	73.5 ab	9.5 a	0.2 b
Dazomet + C-35*	200 lb + 35 gal	63.0 abcd	8.8 a	2.0 b
Dazomet + 1,3-D + pic*	200 lb +15 + 200	75.0 ab	9.2 a	0.8 b
Metam sodium*	75 gal (320 lb)	81.6 a	9.5 a	1.8 b
LSD 0.05	------	18.64	1.347	3.828
Probability	------	0.0076	0.046	0.0345

* Number of open flowers per 10 feet of bed, 4/18/02

** Evaluated 3/18/02, 10 = vigorous, 0 = dead.

Preplant fumigation before Ranunculus plantings. – Mellano--2001

In cooperation with Mellano Flower, Inc. a study was established October 29, 2001 at the Flower Farms Ranch, Carlsbad east of Carlsbad, CA.

The site had been sprinkler irrigated, disked and rototilled to prepare the soil. The sandy loam soil was fluffy and moist. The wet part of the study was about 40% moisture (in untilled soil) and the dry side about 25% moisture. In the tilled area before planting the moisture was only reading ~ 12%.

Resident weed populations expected include cheeseweed, with potential of Aster weed species from blow in source to the north, black nightshade and goosefoot. Wild mustard was broadcast seeded in all plots in rep 3 and 4 toward the north end before treatment and tarping.

Treatments were applied on October 29, 2001. The treatments and specifics were:

Treatment	Rate	method
1) Methyl bromide (50/50%)	350 lb/A	shanked and tarped (red)
2) iodomethane + chloropicrin(50/50)	300	shanked and tarped (pink)
3) iodomethane + chloropicrin	350	shanked and tarped (blue)
4) control (tarped)		(yellow)
(DRY SIDE)		

1) metam + Telone C-35 (pink)	75 gal + 35 gal	incorp/rolled + shanked + tarp
2) metam + Tel II + Pic (blue)	75 gal + 200 + 15 gal	incorp/rolled + shanked + tarp
3) metam sodium (red)	75 gal	incorp/rolled + tarp
4) Dazomet +Telone C-35 Yellow)	200 lb + 35 gal	incorp/rolled + shanked + tarp
5) Dazomet + Telone II + Pic (white)	200 + 15 gal + 200	incorp/rolled + shanked + tarp
6) Control (tarped) (orange)		

(WET SIDE)

Tarp is a 0.001 (1.1 mil) polyethylene sealed around the edges with soil (no gluing)

Treatment plots: Each plot is 150 feet long. Plots vary in width. On the wet side the plots are 13 feet treatment and incorporation and rolled to 15 feet. The plastic covers 11 feet. In the dry side the plot treated area is 11 feet and tarped at 11 feet. With borders the wet is 13 feet and the dry is 15 feet.

Treatments were applied using shanks, blade, tiller and roller. These were followed using shank rig and plastic layer. <u>All treatments are in the center of the plot.</u>

The tarps were cut after one week, allowed to air for 48 h and then pulled. Two beds were formed in the center of the plots and planted with two seed lines per bed.

Weed counts were taken on January 11, 2002 using a 1 foot by 4 feet quadrat in the center of the bed (two subsamples per plot, which were averaged). On January 22, a second sampling of weeds were taken: (quadrat 2.5 feet long and 2 feet wide, across the bed top).
Ranunculus seedlings were counted from 2.5 linear feet of row (mean of two seed lines per bed).

Data were analyzed using MSTAT for a randomized block design with four replications. Means were separated using Fischers Protected LSD (P = 0.05)

2	1	4	3	4	2	1	3	3	4	2	1	3	2	4	1

1) Mbr/pic	350 lb/A
2) iodomethane/pic	300 lb/A
3) iodomethane/pic	350 lb/A
4) Control tarped	

6	1	5	3	4	2	1	3	2	6	4	5	3	2	6	1	5	4	3	5	1	4	6	2

1) metam + C-35	75 gal + 35 gal
2) metam + Telone II + Pic	75 gal + 15 gal + 200 lb
3) metam	75 gal
4) dazonet + C-35	151 lb/A +35 gal
5) dazonet + Telone II + Pic	151 lb/A + 15 gasl + 200 lb/A
6) Control tarped	

Table. Vigor of Ranunculus planted from seed after preplant drip irrigation of fumigants Carlsbad CA 2002

Treatment	Rate (lb/A)	20 weeks	25 weeks
Metam	320	7.4 ab	8.6 a
Iodomethane + chloropicrin	350 (50:50%)	6.0 b	7.4 a
Chloropicrin	200	7.2 ab	8.8 a
Chloropicrin	300	7.2 ab	7.8 a
Sodium azide	60	8.1 a	7.4 a
Sodium azide	100	7.0 ab	6.8 a
1,3-D + chloropicrin (Inline)	400	6.4 b	7.8 a
Untreated control	---	5.8 b	6.6 a
LSD (0.05)	---		NS
P value	---	0.0053	0.2644

Table Ranunculus stand vigor evaluation (evaluated as how closed the furrow was with plant material, 100 = total closure)—North Trial

Treatment	Rate	Closure (%)
Metam* + C-35**	75 gal + 35 gal	32 a
Metam* + 1,3-D + chloropicrin**	75 + 15 + 200	54 a
Metam*	75	58 a
Dazomet* + C-35**	200 lb + 35 gal	35 a
Dazomet* + 1,3-D + chloropicrin**	200 + 15 + 200	61 a
Untreated control	---	62 a
LSD 0.05	---	NS
Probability	---	0.3467

*incorporated and power rolled

** shank applied

Note: all treatments tarped with clear polyethylene

Treatment	Rate	Closure(%)	Stand vigor*
Methyl bromide/chloropicrin	350 (50:50)	62 a	8.8 a
Iodomethane/chloropicrin	300 (50:50)	64 a	8.9 a
Iodomethane/chloropicrin	350 (50:50)	34 b	9.0 a
Untreated control	---	80 a	5.5 b
LSD 0.05	---		
Probability	---	0.0012	0.0002

* Stand 0 = no stand, 10 = full stand

Table Weed control and affect on Ranunculus germination from preplant drip applied fumigants – Carlsbad, California

Treatment	Rate (lb/A)	Clover 1/11/02*	Clover 1/22/02*	Sow thistle 1/11/02	Sow thistle 1/22/02	Malva 1/11/02	Malva 1/22/02	Wartcress 1/11/02	Wartcress 1/22/02	Ranunculus 1/22/02
Metam sodium	320	0.0 b	18.2	0.0 b	0.0	0.2 b	0.4	0.0	0.0	41.8
Iodomethane/chlorpicrin	350 (50:50)	0.9 b	29.2	0.0 b	0.0	0.0 b	0.0	0.0	0.0	46.0
Chloropicrin	200	0.5 b	24.4	0.0 b	0.0	0.3 b	0.2	1.2	0.6	46.0
Chloropicrin	300	0.1 b	17.0	0.0 b	0.0	0.4 b	0.2	0.0	0.4	56.2
Sodium Azide	60	0.0 b	28.0	0.0 b	0.4	0.0 b	0.2	0.0	1.6	45.2
Sodium Azide	100	0.0 b	17.0	0.0 b	0.2	0.0 b	0.0	0.0	0.4	47.0
1,3-D + chloropicrin	150 +150	0.0 b	21.6	0.0 b	0.0	0.0 b	0.2	0.0	0.0	41.4
Untreated - water	------	39.1 a	12.4	2.8 a	0.2	1.9 a	0.2	4.4	0.4	41.8
LSD 0.05	------	6.002	NS	0.8662	NS	0.8059	NS	NS	NS	NS
Probability	------	0.0000	0.627	0.0000		0.0005		0.3806	0.2429	

* Evaluated using a 1 foot by 4 feet quadrat on the bedtop on 1/11/02 and a 2.5 feet by 2.0 feet on the bedtop on 1/22/02
Note: The control plots were rough hand weeded between the first and second evaluation rendering the lack of significance between treatments and the untreated plots.

Table Cost of weeding after preplant fumigation through drip irrigation.*

Treatment	Rate	First weeding Hours/A	First weeding $/A	Second weeding Hours/A	Second weeding $/A
Metam sodium	320	26.125	287.40	156.75	1724.25
Iodomethane/chloropicrin	350 (50:50)	434.89	482.80	161.98	1781.73
Chloropicrin	200	50.16	551.80	177.65	1954.15
Chloropicrin	300	57.48	632.20	167.2	1839.20
Sodium azide	60	26.124	287.40	1878.06	2057.61
Sodium azide	100	41.8	459.80	151.53	1666.78
1,3-D + chloropicrin	150+150	41.8	459.80	1172.42	1896.68
Untreated-water	---	47.02	517.30	156.75	1724.25

* principal weed was clover, which was relatively uniform throughout the study.

Table Harvest of Ranunculus bunches after preplant fumigation.*

Treatments	Rate (lb/A)	1st harvest	Bunches 2-8 harvests	Total bunches
Metam sodium	320	17.4	110.8	128.2
Iodomethane/chloropicrin	350 (50:50%)	15.3	112.8	128.1
Chloropicrin	200	18.6	144.0	162.6
Chloropicrin	300	17.2	120.8	138.0
Sodium azide	60	20.0	119.0	139.0
Sodium azide	100	18.4	105.4	123.8
1,3-D + chloropicrin (EC)	400	19.0	124.0	143.0
Untreated--water	---	16.4	127.2	143.6
LSD 0.05		NS	NS	
Probability		0.3023	0.3536	

- All treatments were treated through driplines under clear plastic (2 lines per bed)

Table Harvest of Ranunculus bunches after preplant fumigation.

Treatments	Rate	1st harvest	2nd harvest	Total bunches
Methyl bromide/chloropicrin	350 (50:50)	79.8 a	352.0 a	431.8 a
Iodomethane/chloropicrin	300 (50:50)	81.8 a	375.8 a	457.6 a
Iodomethane/chloropicrin	350 (50:50)	86.0 a	340.5 a	426.5 a
Untreated – tarped	----	66.0 b	221.0 b	287.0 b
LSD 0.05	----		60.134	
Probability	----		0.0011	

Table Harvest of Ranunculus bunches after preplant fumigation.

Treatment	Rate	1st harvest	2nd harvest	Total bunches
Metam + C-35	320 +35 g	102	251.2	353.2
Metam + 1,3-D + chloropicrin	320 +15g + 200 lb	97	260.0	357.0
Metam	320	106.8	250.5	357.3
Dazomet + C-35	200 + 35g	89.8	268.5	358.3
Dazomet + 1,3-D + chloropicrin	200 + 15g + 200 lb	92.5	240.0	332.5
Untreated-tarped	----	92.8	255.5	348.3
LSD 0.05	----	NS	NS	NS
Probability	----		0.7152	

Delphiniums in the greenhouse

Growing larkspur as a cut flower crop

by Delbert S. Farnham and Arthur H. McCain

THE GENUS *DELPHINIUM L.* contains probably 300 or more species (2). Annual biennial and perennial delphiniums occur in nature. Most species are from the north temperate zone. Many species are grown as perennials in borders and wild gardens and have not been modified horticulturally. These are often referred to as "botanical" larkspurs.

The Latin names for horticultural delphiniums can be confusing. Delatum, a native to southern and central Europe, was introduced into cultivation in 1578. The parentage of today's horticultural varieties have characteristics of several species due to hybridization.

Perennial delphiniums offered in the horticultural trade (Table 1) include several strains that may have cut flower potential. The material in the table is based upon catalog listings (6) and not upon evaluation by the authors. Growers should consult seed company representatives to determine if the cultivars are suitable for their local conditions.

CULTURAL PRACTICES—Annual and perennial delphiniums are grown from seed. Because of insect and disease problems, perennial delphiniums should be started each year for flowering the following year. Post noted in 1952 (5) that most available strains of delphinium would respond for greenhouse forcing and lighting. He suggested that most economical greenhouse production consists of sowing seed about October 1, growing the seedling at 50°F and lengthening the day until flowering occurs. In 1980, Auman (3) suggested sowing seed August 1 and maintaining seedlings in a coldframe until planting in a cool greenhouse in November. Plant spacing of 12 × 20 centimeters was suggested. Post found most cultivars would not bloom before March in the greenhouse. The *Ball Redbook* (1) also suggests methods for handling seeds and transplants. Varieties suitable for cut flowers are also discussed.

Plants grown for outdoor production have been produced in two ways. Seed planted in early spring will flower in late summer. More consistent results occur when seeds are sown in September (1) and the plants are flowered the following summer.

DISEASES AND PESTS—Delphiniums are susceptible to a wide range of diseases (4). Verticillium wilt has been one of the most serous problems in California. Preplant soil fumigation should be used whenever verticillium wilt is encountered. Table 2 summarizes diseases of delphinium and means of control.

Serious pests of delphinium include cyclamen mites, two-spotted mites, aphids, thrips, snails, slugs and nematodes. (For current pest control measures please refer to leaflet 2166, "Insect and Mite Control Guide for Outdoor Nursery Crops" and leaflet 2181, "Insect and Mite Control Guide for California Commercial Floricultural Crops." Both publications are available from California cooperative extension farm advisors.)

POSTHARVEST CARE—Shattering of blooms limits long distance shipment of many delphinium cultivars. Hollow stems also reduce the value of some cultivars. Chemical treatment to reduce shattering and to prolong vaselife have not been evaluated. Select shatter-resistant cultivars.

Cultivar	Description	Cut flower adaptation
Pacific Giants	This strain grows over 6 feet high in fertile ground. Nine separate colors available. Double and semi-double flowers.	Plants need staking. Blooms may be too large to ship. Flowers may shatter.
(Belladonna Imp.) D. elatum x D. grandiflorum	Grows to 3 to 3½ feet. Available in light blue, deep blue and white only. Single flowers.	Used commercially as cut flowers. Short plants should eliminate need for staking.
Connecticut Yankees	2½-foot plants produce flowers 2½ inches across. Single blue flowers.	Flowers resist shattering.
Blue Fountains	Pacific giant "type" flowers on plants 2 to 2½ feet high with flowers in various shades of blue.	New cultivar.
D. Blackmore plus Longdon strain	Distinctive broad, conical spikes; mixed colors of blue, mauve and violet.	One of the most permanent and popular garden cultivars.

Table 1. Delphiniums available 1981

Literature Cited

(1) *Ball Red Book.* 1965. George J. Ball Inc., West Chicago IL, 11th ed.

(2) *Hortus Third.* 1976. L.H. Bailey Hortorium, Cornell University, Ithaca NY.

(3) *Introduction to Floriculture,* 1980. Roy A. Larsen, editor. Academic Press, New York NY.

(4) Pirone, Pascal P. 1978. *Diseases and Pests of Ornamental Plants,* 5th ed.

(5) Post, Kenneth. 1952. *Florist crop production and marketing.* Orange, Judd Publishing Co. Inc., New York NY.

(6) Wayside Gardens Catalog. 1981. Hodges SC.

EDITOR'S NOTE: This article appeared originally in "Flower and Nursery Report" published by University of California cooperative extension, summer 1981. To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products not mentioned. Mention of a chemical does not imply guarantee of effectiveness or safety, nor that the chemicals or uses discussed have been registered by appropriate state and federal agencies.

Delbert S. Farnham *is farm advisor, cooperative extension, Santa Cruz and Monterey Counties.* **Arthur H. McCain** *is plant pathologist, cooperative extension, University of California, Berkeley.*

Disease (causal agent)	Symptoms	Survival of pathogen	Effect of environment	Control
Black leaf spot (Pseudomonas syringae)	A bacterial disease, causes irregular, shining, tar-like spots, especially on upper sides of leaves. Spots are browner on opposite side of leaf. Spread in cool, wet weather.	Survives on foliage and stems left from previous year.	Favored by cool wet weather.	Cut and discard old stems and foliage in fall. Fumigate seedbed with chloropicrin-methyl* bromide combination. Grow in clean land or only once in five years on infected land. Avoid overhead irrigation.
Soft crown rot and black leg (Erwinia chrysanthemi) (Erwinia cartovora)	Crown rot: Infection results in rapid wilt and death of plant. Decay gives off strong offensive odor. Black leg causes stunting and killing back, but may later produce healthy branches.	Bacteria are common in soil and plant debris.	Favored by hot humid weather. Avoid overwatering.	Avoid fields known to have disease, or fumigate the soil as described for black leaf spot. This may help, but does not completely eliminate the bacteria.
Crown gall (Agrobacterium tumefaciens)	Galls form at base of plants.	Survives in galls on living plants and in soil for many years.	Favored by moist conditions. Wounds are necessary for infection.	Preplant soil fumigation. Use clean planting stock. Avoid injuries. Allow cuts and wounds to dry thoroughly before the next irrigation.
Crown rots				
1. (Diplodina delphinii)	1. Cankers and necrotic lesions on stems and leaf stock.	Infected soil, tools and cultivation equipment.	1. Favored by excess moisture.	1. Avoid poorly drained soils. Fumigate seed flats and soil mix.
2. (Pythium ultimum)	2. Rot of roots and basil parts.		2. Favored by cool, moist condition.	2. Drench seedlings at two to four week intervals with fenaminosulf (Pythium).
3. (Sclerotium rolfsii)	3. Yellow, brown or buff colored Sclerotia, $\frac{1}{16}''$ to $\frac{1}{8}''$ in diameter, on base of plants and soil.		3. Favored by high moisture and high temperatures.	3. Preplant fumigation. PCNB will help control spread down the row.
Gray mold (Botrytis cinerea)	Basal rot; brown water-soaked basal rot of plants; wooly gray fungus spores form on rotted tissues. Also affects flowers.	Plant debris.	Favored by cool, wet weather.	Protect plants with fungicide.
Stem canker and wilt (Fusarium oxysporum f. delphinii)	Light brown water-soaked lesions on stems, later become brown. Yellowing progresses from base of stem upward.	In the soil for many years.	Disease develops during periods of high temperature.	Use clean flats; grow on clean land or fumigate the soil, as described for black leaf spot.
Smut (Urocystis sorosporioides)	Swellings on stems, leaves, and petioles. Break open to reveal dark masses of spores.	In plant debris and soil. Spores infect seedlings.	—	Treat seed with a fungicide. Remove and destroy infected parts.
Powdery mildew (Erysiphe polygoni, and Sphaerotheca humuli)	White powdery masses of fungus on leaves and stems.	On living plants and as resting structure. Spores are airborne.	Favored by locations having poor air movement.	Select resistant cultivars. Spray with dinocap or benomyl.
Leaf spots (Asochyta aquilegiae, Cercospora delphinii, Ovularia delphinii, Phyllosticta sp., and Ramularia delphinii)	Foliage leaf spotting.	Infected plants and debris.	Favored by moist conditions.	Avoid overhead watering. Protect foliage with a fungicide.
Rusts (Puccinia delphinii)	Orange pustules of powdery spores on underside of leaves.	On living plants.	Favored by free moisture from rain, fog, dew or irrigation.	Protect foliage with dithiocarbamate fungicide.
Verticillium wilt (Verticillium dahliae)	Wilting of single branch or entire plant. Yellowing of lower leaves. Brown discoloration of water-conducting tissues. Common disease in California.	In the soil for many years. Fungus attacks many kinds of plants.	Symptoms most severe during warm weather following a cool period.	Avoid disease-infected fields, or fumigate the soil as described for black leaf spot.
Virus diseases: Ringspot, Calico, Curly-top, Mosaic, Stunt	Various leaf symptoms: color break of blooms.	By leaf sucking insects.	—	Clean up weeds. Eliminate susceptible ornamental plants. Control insects. Eliminate infected plants.
Aster yellows (Mycoplasma-like organism)	Stunting and spindly foliage. Flower petals may be green.	Leafhoppers	—	—

* Requires permit from County Agricultural Commissioner for purchase, possession, or use.

Table 2. Delphinium disease control guide

STOCK

DISEASE CONTROL GUIDE

The author is Arthur H. McCain, Plant Pathologist,
Cooperative Extension, Berkeley.

Cooperative Extension
Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA
LEAFLET
2858
(B)

DISEASE (Pathogen)	SYMPTOMS	SURVIVAL OF PATHOGEN	EFFECT OF ENVIRONMENT	CONTROL
Bacterial blight (*Xanthomonas campestris pv. incanae*)	Basal leaves turn yellow and drop. Leaf scar is blackened. Soft, water-soaked stem cankers later become dark and sunken. Black discoloration of the vascular system occurs.	Seedborne and in plant debris; also in the soil for 2 years.	Favored by cool, wet weather. Bacteria are spread by water.	When buying seed, specify that it be grown from seed treated in hot water (50° to 55° C for 10 minutes). Follow a 3-year crop rotation.
Foot rot or Wire stem (*Rhizoctonia solani*)	Brown rot of stem occurs at the soil line; area later becomes a dry, sunken canker. Stems are girdled. Brown fungus strands are visible with a hand lens. Also causes damping-off of seedlings.	Soilborne fungus.	Favored by warm, moderately moist soil.	Spray benomyl over the row and bases of plants.
Water-mold root rot (*Phytophthora* and *Pythium* species)	Plants wilt easily or suddenly collapse. Roots and crown become decayed. Also causes damping-off of seedlings.	Soilborne fungi.	Associated with poorly drained, waterlogged soils. Spores are spread in water.	Provide drainage and avoid excessive irrigation. Plant on raised beds. Seed treatment helps control damping-off phase.
Sclerotinia or Cottony rot (*Sclerotinia sclerotiorum*)	Girdling stem infections that cause stems to turn chalky white. Cottony masses of fungus or large, black sclerotia develop inside stems.	As sclerotia in the soil. Airborne spores produced by sclerotia.	Favored by cool, moist conditions.	Avoid fields where disease has occurred (common disease of many vegetable crops). Spray foliage with benomyl.
Botrytis blight (*Botrytis cinerea*)	A soft, brown decay occurs on the flowers or entire flower heads. Woolly, gray fungus spores form on decayed tissues. Decay may also start on dead leaves and rot the growing points and flower buds.	In plant debris.	Favored by cool, moist conditions.	Protect flowers with benomyl or captan. Watch for benomyl resistant forms of the fungus.

Verticillium wilt (*Verticillium dahliae*)	Foliage yellows and wilts. Leaves die and dry up progressively upward from the base of the plant. Dark discoloration of the vascular system occurs.	Soilborne as micro-sclerotia for many years.	Symptoms most severe when weather turns warm after a cool period.	Avoid fields where disease has occurred or fumigate the soil with a methyl bromide-chloropicrin combination*[1] (tarped). This combination also controls most weeds, nematodes, soil insects, and other fungi and bacteria.
Fusarium wilt (*Fusarium oxysporum* f. *mathioli*) (Important in seed fields)	Leaf veins first turn yellow, then entire leaf becomes yellow, withers, and drops. Basal leaves are affected first. Plants are stunted. Seed pods turn a light-tan color. Brown vascular discoloration occurs.	Soilborne for many years; seedborne.	A warm-weather disease; rarely a problem in the winter grown, cut-flower crop.	No control necessary for the cut-flower crop grown in cool, coastal areas. Fumigate the soil (see Verticillium wilt control).
Leaf spot (*Alternaria raphani*)	Round to elongate, concentric, brown spots covered with black, powdery spores develop. Spots are small at first, then turn gray-green with water-soaked margins.	On growing stock, cruciferous weeds, and crop refuse.	Favored by wet weather.	Plow under plants as soon as the flowers are harvested. Destroy all plant refuse. Spray with a copper fungicide during wet weather.
Mosaic (Several viruses)	Leaf mottling and flower breaking occur. Leaf symptoms vary with different viruses. White and yellow varieties do not show flower breaking.	In cruciferous weeds (mustard, wild radish, shepherd's purse, etc.). Spread by aphids. Not seedborne.	Symptoms favored by cool weather.	Destroy nearby weeds. Avoid fields near uncontrolled weedy areas. Plow under stock as soon as the crop is cut. Control aphids; only partly effective since the plants may become infected before the aphids are killed.

* In California, a permit for purchase or use is required from the county Agricultural Commissioner.

[1] CAUTION: Methyl bromide and chloropicrin are extremely hazardous materials. Anyone using them or planning to use them should become familiar with and strictly follow the warnings on the package label or any accompanying material furnished by the manufacturer.

GLADIOLUS DISEASE CONTROL GUIDE

DISEASE (Causal Agent)	SYMPTOMS	SURVIVAL OF PATHOGEN	EFFECT OF ENVIRONMENT	CONTROL
Fusarium yellows (*Fusarium oxysporum* f. *gladioli*)	Leaves yellow progressively and die prematurely. Brown rot of corms begins in the basal plate and core and extends upward into the leaf bases via the vascular strands. Corms may rot in ground or while in storage. Varieties vary in symptoms and susceptibility. Infection without obvious symptoms is common.	In diseased corms and in infested soil for many years.	Favored by wet soil and temperatures of 70° F. or above.	Plant disease-free corms in clean soil, or grow resistant cultivars. Hot water treatment of cormels eliminates the disease from infected stocks. Cure and treat corms as outlined. Fumigate infested soil with methyl bromide-chloropicrin* combination.
Stromatinia (*Stromatinia gladioli*)	Leaves yellow and die. Leaf sheaths rot at soil level (neck rot). Rotted tissues appear shredded. Numerous, very small, black fungus resting structures (sclerotia) are imbedded in dead tissue. Corm lesions are dark brown and sunken with raised margins.	On diseased corms and in the soil for 10 years or more.	Favored by wet soil.	Cure and treat corms as outlined. Use uninfested or chemically treated land. Fumigate soil with MIT or methyl bromide-chloropicrin* combination. If soil is not fumigated, treat furrow at planting time with dicloran.
Botrytis (Botrytis blight, Neck rot, Corm disease) (*Botrytis gladiolorum* and *Botrytis cinerea*)	Tiny, brown leaf spots develop; spots may expand or coalesce. Brown, watersoaked spots appear on flower petals. Basal stem infections (neck rot) may penetrate corm; corm decay may continue in cold storage. Woolly, gray fungus spores may form on decayed tissues. Black, seed-like sclerotia may form on underground parts.	In corms and on crop refuse. Spores are airborne.	Favored by moist conditions and cool temperatures — 50° to 70° F.	Complete control program essential in coastal areas: cure and treat corms as outlined; spray with beyomyl or mancozeb at 14-day intervals. To prevent development of benomyl-tolerant strains of *Botrytis*, combine benomyl and mancozeb. After harvest and before packing, spray flower spikes with dicloran.

*CAUTION: Permit from county Agricultural Commissioner required for purchase or use. Methyl bromide and chloropicrin are extremely hazardous materials. Anyone using them or planning to use them should become familiar with and strictly follow the warnings on the package label or any accompanying materials furnished by the manufacturer.

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DISEASE (Causal Agent)	SYMPTOMS	SURVIVAL OF PATHOGEN	EFFECT OF ENVIRONMENT	CONTROL
Stemphylium leaf spot (*Stemphylium* species)	Small, round or angular, yellow spots with a red dot in the center appear on green parts of plants. Spots are larger on some varieties. Varieties differ in susceptibility.	Carried over on gladiolus foliage and refuse.	Favored by warm, wet weather, especially sprinkler irrigation and rain.	Spray with zineb, maneb, or mancozeb at 10- to 14-day intervals. Plow under gladiolus refuse.
Scab (*Pseudomonas gladioli*)	Mainly seen on the corms as brown, irregular or round, sunken spots with a shiny, brittle, varnish-like material (bacterial exudate) on the surface.	On corms and in soil refuse for 2 years.	Favored by heavy, wet soils and warm weather. Encouraged by heavy nitrogen fertilization.	Rotate every 3 years. Control measures for other diseases usually take care of scab. Control chewing insects in the soil.
Rhizoctonia neck rot (*Rhizoctonia solani*)	Stem below ground and husks at harvest appear shredded. Brown fungus strands (mycelium) visible with a hand lens.	Common soilborne fungus with wide host range.	Favored by wet weather.	Corm dips help control the disease. Sprays of benomyl should reduce spread of the disease down the row.
Penicillium corm rot (*Penicillium gladioli*)	A firm, brown corm rot develops in storage; frequently in association with other corm rots. If conditions are moist, greenish-blue spore masses appear over rotted areas.	On corms and corm debris and as spores on storage-room equipment.	Rot develops rapidly when humidity is high.	Cure and treat corms as outlined.

DISEASE (Causal Agent)	SYMPTOMS	VECTOR	OTHER HOSTS	CONTROL
Mild mosaic (Bean yellow mosaic virus)	A faint leaf mottle and sometimes a pencil-stripe color break of blossoms. Disease is common in nearly all gladiolus varieties.	Aphids. Mechanically transmitted by harvesting tools.	Legumes (beans, peas, vetch).	
White streak (Cucumber mosaic virus)	White streaking of leaves and a white streak of the blossom.	Aphids. Sometimes transmitted by harvesting tools.	Cucurbits (melons, cucumber, squash).	
Ringspot (Tobacco ringspot virus)	Yellow or white ring patterns and blotches on leaves.	Nematodes. Mechanically transmitted by harvesting tools.	Many kinds of plants, including weeds.	Propagate from selected disease-free plants grown in isolated areas. Rogue infected plants at flowering time, or as soon as virus symptoms appear.
Grassy top (Aster yellows mycoplasma)	Current season infection results in early maturity, small corms, and arrested root development. Next	Leafhoppers	Many kinds of plants, including some weeds.	

White break	White blotches on flowers. Flowers open poorly and may shrivel prematurely.	Corm propagated. Vector unknown.	Unknown.
Stunt	Plants are stunted and produce short spikes. Virus nature not proved. Disease commonly affects Chamouny, Spic and Span, and Elizabeth the Queen cultivars.		

Septoria leafspot (*Septoria gladioli*) and **leaf smut** (*Urocystis gladiolicola*) are rare diseases in California.
Curvularia leafspot (*Curvularia lunata*) appears occasionally as a neck rot, particularly in cormel stocks.

CARING FOR CORMS

The major gladiolus diseases can be carried on the surface of or inside the corms. To control disease, it is essential to correctly cure, store, and dip the corms before planting.

Curing. Immediately after digging, place the corms in shallow trays in storage rooms maintained at 95° F and 80 percent relative humidity. Use fans to circulate air through and around the corms. When old corms break off easily, usually after 6 to 8 days, clean them and then dust them with thiram. Return corms to storage at 95° F and 80 percent relative humidity for 4 more days.

Storage. Store cured corms at 40° F and 70 to 80 percent relative humidity.

Preplant dip. Before planting, dip corms in benomyl, folpet, or thiabendazole plus 4 to 6 fluid ounces of wetting agent per 100 gallons of water. The water should be at a temperature of 80° to 90° F. If benomyl-tolerant strains of *Fusarium* or *Botrytis* are suspected, use folpet or thiram in combination with benomyl and thiabendazole. Allow corms to dry before planting.

Sanitation. Maintain sanitary storage facilities. Burn all gladiolus refuse. Steam treat or disinfect trays, tools, and the like with formalin (37% at 1 gallon per 18 gallons of water).

Hot water treatment of cormels

1. Select sound, hard, fully dormant cormels grown in warm soil and harvested before cold weather. Cure as outlined, but omit the fungicidal dust.
2. Presoak cormels for 2 days in water when the air temperature is 60° to 80° F. Discard any corms that float.
3. Soak cormels for 4 hours in a solution of commercial formaldehyde (37 percent to 40 percent) diluted 1:200 with water.
4. Immerse 30 minutes in water heated to 135° F ± 1°.
5. Cool immediately with clean, cold water.
6. Dry thoroughly and quickly in warm air or sunshine.
7. Dust with thiram and store at 40° F and 70 to 80 percent relative humidity.

Floriculture's Changing Face

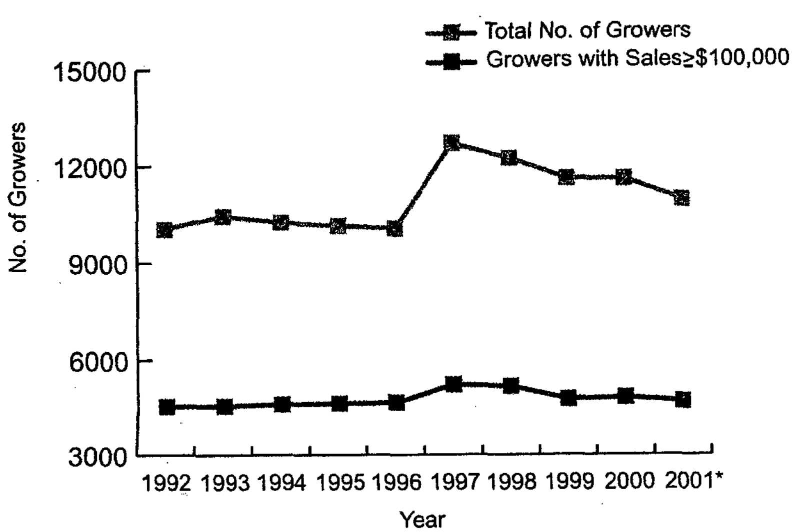
by Marvin N. Miller

Our annual look at the USDA Floriculture Crops Summary points to an industry that's evolving, with probable dramatic change in the offing

At the end of April, the U.S. Department of Agriculture's National Agricultural Statistics Service (USDA/NASS) released its *Floriculture Crops: 2001 Summary*. This annual survey of the 36 leading states' floricultural production and sales contained a few surprises, some of which suggest the industry may be poised for major change!

USDA continues to survey growers with at least $10,000 in wholesale sales. Growers with at least $100,000 in wholesale sales are asked to report a crop-by-crop analysis of their sales figures. Smaller growers only provide figures on their production space and an indication of a range in which their total sales fall. ▶

Figure 1
Grower Numbers



MAJOR TRENDS

1. Growth in the industry has slowed significantly in the last year.

2. Grower numbers are consolidating, yes; but the "larger growers" may not be consolidating as quickly as we think.

3. Overall production space has hardly changed, but it's in fewer hands.

4. The large states are getting larger. California now has over $1 billion in floriculture production by itself (bigger than the entire industry 20 years ago, not counting for inflation).

5. Bedding/garden plants (including perennials) make up more than half of the industry's production.

6. Bedding/garden plant growth is no longer the fastest growth segment of the industry. Both foliage plants and pot plants beat out bedding/garden with faster growth rates from 2000 to 2001.

7. Perennials were 22.4% of bedding/garden plant sales in 2001. But perennial sales increased 12.4% from 2000 to 2001, while sales of annuals increased at a dismal 1.7% over the period. (Some of this could be because perennials are a newer category and growers are getting up to speed on reporting this, but perennial sales are still growing faster, according to the data.)

8. Flats of flowering annuals are now only 36.5% of the bedding/garden plant segment's sales dollars. Unit sales of flats continue to decline.

9. Unit sales of mainstays such as geraniums are also waning.

10. Garden mum sales may have also peaked. In any case, this mainstay of the fall market is no longer growing as fast.

11. Potted bedding/garden plants and hanging baskets continue to rise.

12. Pot plant producers are making more money by altering their product mix, rather than by increasing their units.

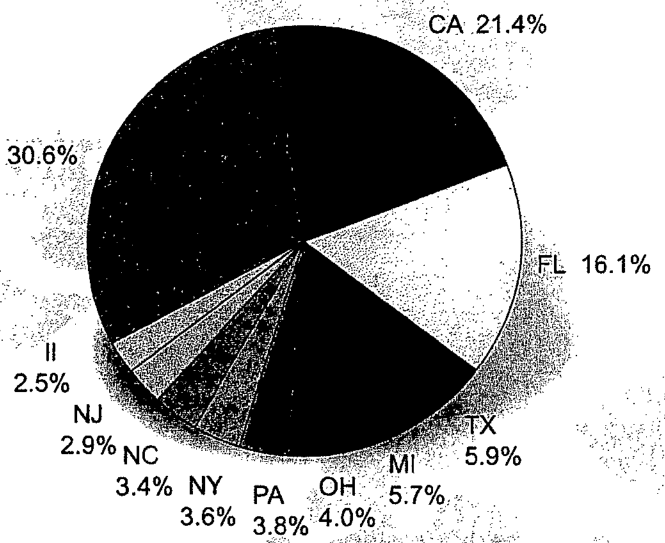
13. Foliage plant sales are growing faster than other segments' sales.

14. Cut flower sales continue to decline.

15. Change is a constant!

—M.M.

Figure 2
Top Floriculture Production States
$ Sales for 2001



JSDA releases what end up being pre-
iminary statistics each year, as well as
evised numbers from the previous
year.

TOTAL SALES, GROWERS AND AVERAGES

The expanded total for all floricul-
ural sales (wholesale value), which
ncludes an approximation for the
smaller growers, was $4.739 billion for
2001 for the 36 states, up 3.5% from a
evised $4.577 billion for 2000. Larger
growers, those with at least $100,000
n sales (41.7% of all growers in 2000
und 43.1% of all growers in 2001),
eported $4.435 billion in sales in
2001 (93.6% of all sales), up 4.3%
rom a revised $4.254 billion in 2000
93.0% of all sales). Omitting sales of
propagative materials and unfinished
plants for these larger growers indicat-
d the total finished floricultural pro-
luction value for 2001 sales was only
$4.129 billion, up a more modest 2.9%
rom the similar figure for 2000. Com-
paring this 2.9% finished production growth rate to the approximate 6.1% rate (revised) from a year ago suggests that while sales are still increasing, the industry sales growth rate (for 2001) has slowed significantly.

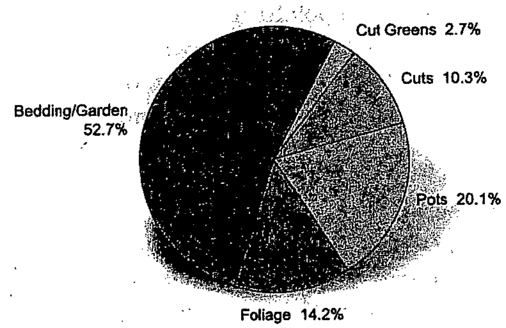
Growers. As Figure 1 (page 86) suggests, there has been a consolidation in grower numbers. The preliminary numbers for 2001 suggest there were 5.7% fewer growers, a drop to 10,965 growers from the revised 11,624 reporting in 2000 (Figure 1). (A year ago, USDA reported only 10,873 growers, which suggested a drop of 752 growers from 1999. However, the revised 2000 total suggests there was only one less grower in 2000 than the 11,625 growers reported in 1999.) There were 4,722 growers with at least $100,000 in sales in 2001, down 2.7% from the 4,851 so-called "larger growers" in 2000. In fact, a decline in grower numbers was reported across the board in every sales range within the survey. However, there were 11.2% fewer growers in 2001 with sales less

(Continued on page 93)

(Continued from page 88)
than $50,000 than in 2000, but only 2.9% fewer growers in 2001 with sales of $50,000 or more.

Sales. The average grower had sales of $432,162 in 2001, up 9.8% from 2000. The revised 2000 figure for average sales was $393,719 per grower, which was up 11.7% from 1999, so average sales growth also slowed in the most recent year. For growers with at least $100,000 in sales, the average sales figure was more than doubled at $939,296 for 2001, but the figure only grew 7.1% from 2000's revised $876,928, a somewhat lower growth rate than for all growers for the 2000-2001 period. The average 2000 sales figure was up 11.4% for these larger growers from 1999. Omitting sales of propagative materials and unfinished plants, the average larger grower had $874,497 in sales of finished floricultural products in 2001, just 5.8% higher than the 2000 average. However, the 2000 average sales of finished floricultural products for these larger growers was up 5.1% from 1999, suggesting a greater sales growth rate for finished products from the larger growers in the last year.

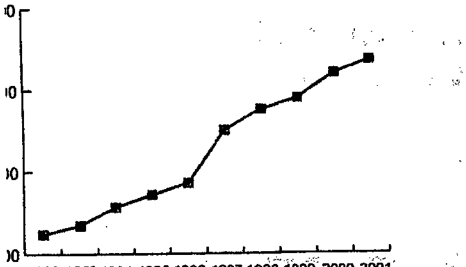
Figure 3
The 2001 U.S. Floriculture Production Pie
$4.129 Billon in Sales
(Finished Product Only—Wholesale Value)



HOW LARGE?

Total covered production space reported in the 36 major production states changed little from 2000 to 2001 (up 0.1%), but that space was in fewer hands. Overall, greenhouse space ▶

Figure 4
Total Bedding/Garden Plant Sales Dollars



reased 0.8% to 541.48 million sq. ft., le shade and temporary cover space lined 0.9% to 389.81 million sq. ft. tdoor production acreage increased 1 % to 41,110 acres. However, due he decline in the number of growers orting, the average greenhouse space reased 6.9% from 46,209 sq. ft. 06 acres) to 49,382 sq. ft. (1.13 es) per grower. The average shade l temporary cover space increased % from about 33,851 sq. ft. (0.78 es) to 35,550 sq. ft. (0.82 acres) per wer. And the average outdoor production space increased about 0.57 res per grower, up 17.9%, to 3.75 res.

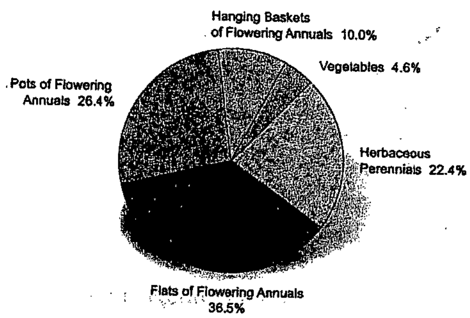
For growers with at least $100,000 in olesale sales, the average greenhouse oduction space increased about 4,522 . ft., up 4.7%, to 100,038 sq. ft. (2.3 res); the average shade and temporary ver space increased 1,412 sq. ft., up 9%, to 75,906 sq. ft. (1.74 acres); and tdoor production space increased an erage 1.1 acres per grower, up 17.7%, 7.3 acres.

TATE RANKINGS

The state rankings held a few surises. As usual, California led all proiction states (Figure 2, page 88), and alifornia accounted for over $1 billion sales for the first time ($1.016 billion) and represented 21.4% of all ported production. To put this mileone into perspective, the entire *Floriulture Crops Summary* in 1981 (for 28 states) was less than California's sales volume for 2001. Florida ranked second and accounted for 16.1% of the total sales ($765.0 million) in the survey. These two states accounted for 37.5% of total production.

As often occurs, Texas and Michigan swapped places from a year ago, with Texas ranking third in 2001 sales, accounting for 5.9% of total sales ($277.6 million), while Michigan ranked fourth with 5.7% of total sales ($270.1 million). Ohio held onto its traditional fifth place ranking, accounting for 4.0% of sales ($189.9 million). These five states accounted for over half (53.1%) of total sales in the survey.

Figure 5
Sales of Bedding/Garden Plants - 2001



For the first time ever, Pennsylvania outranked New York, with the former ranking sixth and accounting for 3.8% of sales ($180.6 million), and the latter ranking seventh, accounting for 3.6% of sales ($172.4 million). (However, if you only consider finished floricultural production, New York still out produces Pennsylvania.)

Only three other states, North Carolina (3.4% of the total at $161.4 million), New Jersey (2.9% at $137.0 million), and Illinois (2.5% at $117.5 million), accounted for more than $100 million in total sales. These 10 states accounted for 69.4% of the reported total sales. Due to a particularly hard-hitting recession in the state, Washington's sales dropped below $100 million for the first time ice 1998, falling 4.9% from 2000 to ly $98.4 million. In total, only 25 of e 36 states reported more sales dollars 2001 than in 2000.

IDUSTRY SEGMENTS

Examining the finished floriculture oduction by industry segment (Figure page 93) revealed additional surpris-. The bedding/garden plant segment ;ain dominated the production, counting for 52.7% of the finished oduction for growers with at least .00,000 in sales. This was up from :.2% (revised) of the 2000 pie. Overl, the bedding/garden plant segment counted for $2.177 billion in 2001, 3.9% from 2000. The other segents, potted flowering plants (20.1% 2001 sales), foliage plants (14.2% of 01 sales), cut flowers (10.3% of 2001 les), and cut cultivated greens (2.7% 2001 sales) all maintained their nkings, and 2001 shares remained thin a half percentage point of vised 2000 shares. However, the owth rate of sales of foliage plants, iich increased by 4.5% from 2000 to 01, and potted flowering plants, iich increased 4.0% over the period, itpaced the 3.9% increase in sales of dding/garden plants.

While the growth in bedding/garden ant sales exceeded the overall indus-'s sales growth rate, the fact that the les growth rate for bedding/garden ants hasn't led all segments for three ars now could be signaling a major ange for the industry.

In 1999, the sales growth rates of th cut greens and cut flowers exceed-l that of the bedding/garden plant ctor. With the revised 2000 figures, it w becomes apparent that the foliage ctor's sales growth rate surpassed at of the bedding/garden plant sector d all other industry segments in 00, and it appears to have repeated at with the 2001 preliminary num-rs. (It should be noted that, in 2000, SDA changed the way growers report-l their foliage plant sales to include l wholesale sales of foliage, rather▸

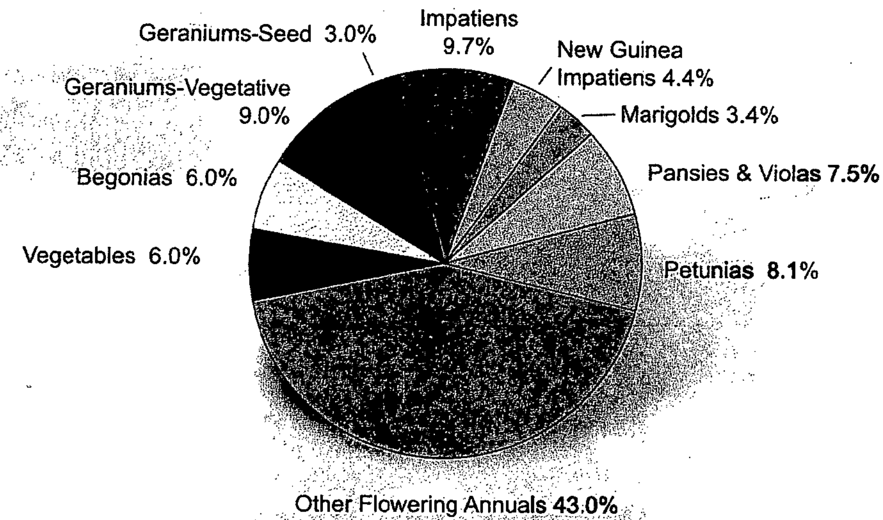
than the net value of gross sales less the cost of plant materials purchased from others for growing on. The 2001 figures confirm that foliage is growing faster than other industry segments.)

With the preliminary 2001 data, the sales growth rate of the potted flowering plants category also appears to have surpassed that of bedding/garden plants. The bedding/garden plant segment's sales growth has exceeded the growth rates of all of the industry's segments nine of the 17 years since the 1984-85 comparison, and it has not been in the third position since 1990. Change is very apparent!

BEDDING/GARDEN PLANTS

As noted above, sales of bedding/garden plants rose 3.9% in 2001 to $2.177 billion. This follows a continuous pattern of increases over the years (Figure 4, page 94).▶

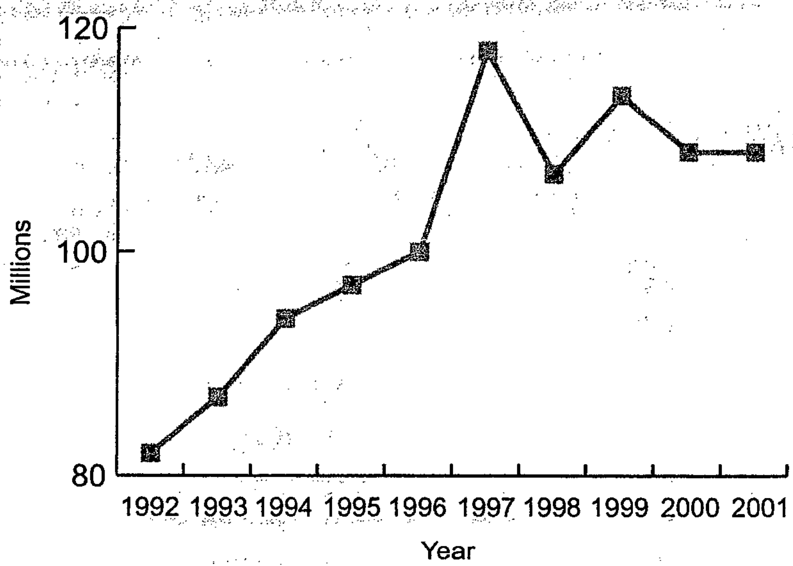
Figure 6
Dollar Distribution
Sales of Annuals - 2001



However, the rate of sales increases in the bedding/garden plant segment of the industry appears to be slowing. Indeed, 1999's 3.8% growth and 2001's 3.9% growth, which were interrupted by 2000's 7.8% growth, were the only two times since 1988 that this segment has recorded less than 4% growth from one year to the next.

Perennials vs. annuals. For the first time, USDA has provided a year-to-year comparison of perennial sales in this annual report. Considered part of the bedding/garden segment, sales of perennials increased 12.4% from 2000 to 2001, compared to a much slower growth rate for annuals, which increased only 1.7% over the period. Perennials were valued at $487.7 million in 2001, while annuals contributed $1.689 billion to the segment's total sales. Overall, there were almost $4 in sales of annuals to every $1 of peren-▶

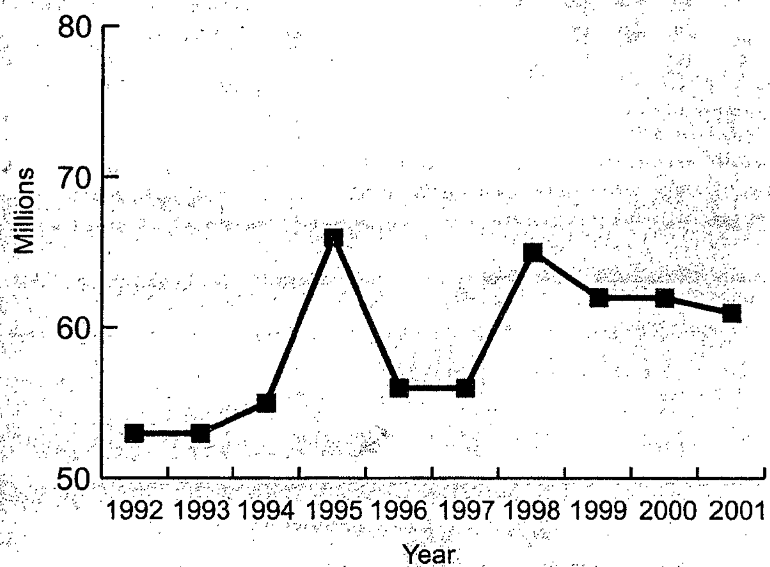
Figure 7
Total Sales of Bedding/Garden Plants
Units of Flats



nial sales, as the latter category contributed only 22.4% of the bedding/garden plant segment's total sales. Garden mums accounted for 21.2% of all reported perennial sales, hostas accounted for 8.0%, and other perennials accounted for the remaining 70.8% of perennial sales in 2001.

Bedding Breakdown. Sales of bedding/garden plants in 2001 were composed of 36.5% annual flowering flats, 26.4% pots of flowering annuals, 10.0% hanging baskets of flowering annuals, 4.6% vegetables, and 22.4% perennials (Figure 5, page 95). Total sales of flowering bedding plant flats were off 0.5% in units (to 100.0 million flats) and off 1.2% in dollars (to $795.2 million) from 2000 to 2001. Sales of vegetable bedding flats increased 0.6% in units (to 8.7 million flats) and increased 5.0% in dollars (to $72.0 million) over the two-year period.▶

Figure 8
Sales of Potted Vegetative Geraniums
Units



INDUSTRY GROWTH

Sales of pots of flowering annuals increased 0.5% in units (to 441.1 million pots) and rose 4.1% in dollars (to $575.3 million) from 2000 to 2001. Sales of potted vegetables declined 8.2% in units (to 27.4 million pots) and dropped 3.6% in dollars (to $28.7 million) over the period. Total hanging basket units were up 1.7% in units (to 38.4 million baskets) and rose 5.9% in dollars (to $217.9 million) from 2000 to 2001.

Due to the first-time addition of begonias, marigolds and pansies/violas to the survey in 2000 and to the further breakout of all bedding plant species into flats, pots and hanging baskets (including a further breakout of seed vs. vegetative geraniums in these categories), one could argue that the species data is still in flux. Indeed, when changes such as these have occurred in this survey in the past, there has often been a three-▶

Figure 9
Garden Mums
Units

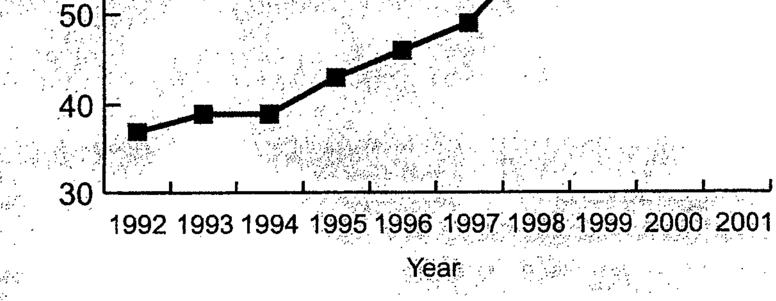
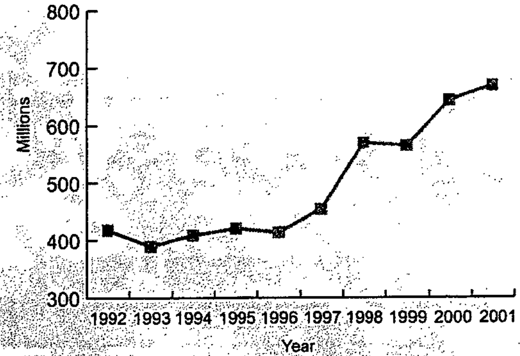


Figure 10
Sales of Potted Flowering Bedding/Garden Plants
(Including Perennials)
Units



year period before data are considered reliable. Perhaps as a result of the recent addition, the annual species picture looks more different from using the revised 2000 numbers relative to the preliminary numbers issued last year, than when comparing the revised 2000 numbers to the preliminary 2001 data. Still, the species have changed in importance to the total segment's sales.

Sales of vegetative geraniums were off in flats and in pots (but up in hanging baskets), contributing to a decline in importance from 9.3% of sales in 2000 (revised) to 9.0% of bedding/garden plant sales in 2001 (Figure 6, page 98). Likewise, unit sales of seed geraniums were off in flats, pots and hanging baskets, contributing to another decline in importance, from 3.2% of 2000 sales to 3.0% of 2001 sales.

Unit sales of New Guinea impatiens were off in flats and pots but up in baskets; this led to a decline in importance from 4.5% of segment sales in 2000 to 4.4% of sales in 2001. *Impatiens wallerana* sales also dropped in importance, as unit sales of flats and hanging baskets declined; the importance of this species to the overall bedding plant mix dropped from 9.9% in 2000 to 9.7% in 2001. In contrast, the importance of begonias, marigolds, pansies/violas, petunias and vegetables all increased in 2001 sales. The importance of other flowering annuals also declined in 2001.

Long-term trends. Some longer-term trends in the bedding area are worth noting. First, sales of a number of key bedding/garden plant items, most notably flats of annuals and vegetative geraniums, appear to have peaked in▶

Figure 11
Sales of Flowering Hanging Baskets
Units

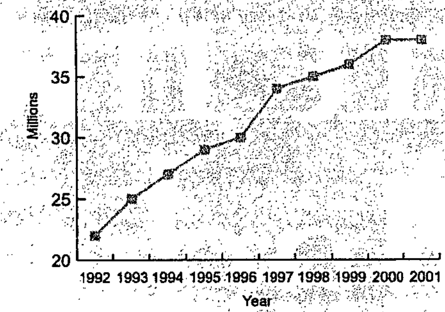


Figure 12
Sales of Potted Flowering Plants
Units

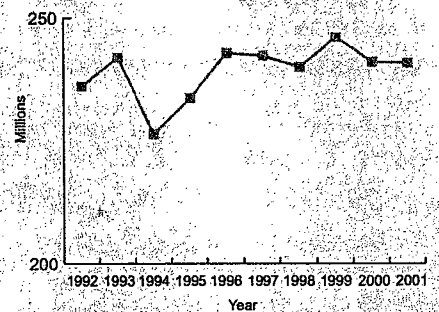
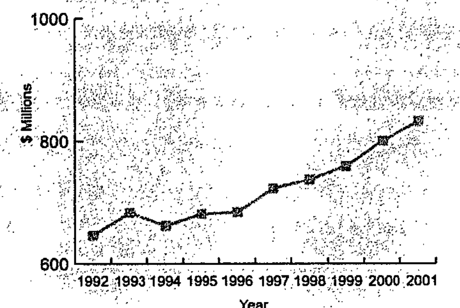


Figure 13
Sales of Potted Flowering Plants
Dollars

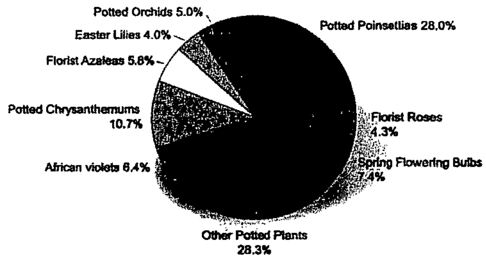


recent years and have begun to decline in the numbers of units sold. As Figure 7 (page 100) shows, unit sales of bedding plant flats peaked in 1997. Unit sales of potted vegetative geraniums have fluctuated widely over the years, peaked in 1995, and have declined for the last three years in a row (Figure 8, page 102). The top perennial item and the mainstay of

(Continued on page 113)

(Continued from page 108)

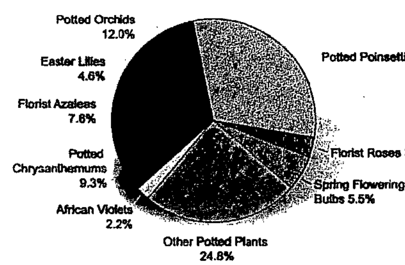
Figure 14
Sales of Potted Flowering Plants - 2001
Units



the autumn season, the garden mum, also may be showing some vulnerability. The preliminary 2001 statistics show a decline in numbers sold for the first time (Figure 9, page 104), perhaps, related to September 11; however, the unit growth rates of the past few years have been declining.

In contrast, the unit sales of potted flowering bedding/garden plants, which would include mixed containers, have been on the rise, especially if perennials (including garden mums) are included in the mix (Figure 10, page 106). And unit sales of flowering hanging baskets also appear to be a relatively bright spot (Figure 11, page 108).

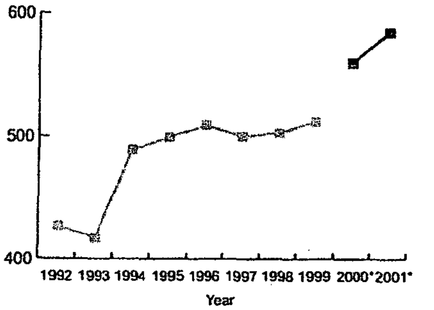
Figure 15
Sales of Potted Flowering Plants - 2001
Dollars



POTTED FLOWERING PLANTS

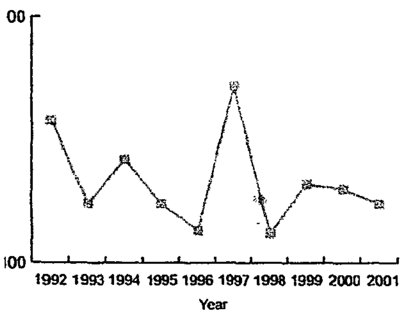
The story of potted flowering plants is interesting. Overall, unit sales were virtually unchanged for the segment, with unit sales down less than 0.1% to 240.8 million pots (Figure 12, page 108). In dollar terms, the segment's sales were up 4.0% to▶

Figure 16
Sales of Foliage Plants
Dollars



*1992-1999 represent a net value of gross sales less the cost of plant materials purchased from others for growing on. 2000-2001 represent the total wholesale value of all sales.

Figure 17
Sales of Cut Flowers
Dollars



31.9 million, continuing a fairly consis-
it rise in value over the last decade
gure 13, page 108). Obviously, growers
: altering the mix of varieties produced
maximize sales revenues.

There were some wide swings within
: segment as four species gained and
e species lost in unit sales. Easter lilies
› 4.8% in units sold), orchids (up
.0%), poinsettias (up 1.5%), and spring
lbs (up 17.8%) were "the winners."
rican violets (down 5.4% in units sold),
rist azaleas (down 6.4%), chrysanthe-
ims (down 9.0%), florist roses (down
.2%) and the "other potted flowering
ints" (down 1.7%) all lost ground.

As Figures 14 and 15 (page 113)
pict, poinsettias continued their domi-
nce in the segment in terms of individ-
l species in both units (28.0%) and
llars (30.8%). In terms of units, pot
ims ranked second among individual
ecies (10.7% of units), followed by▶

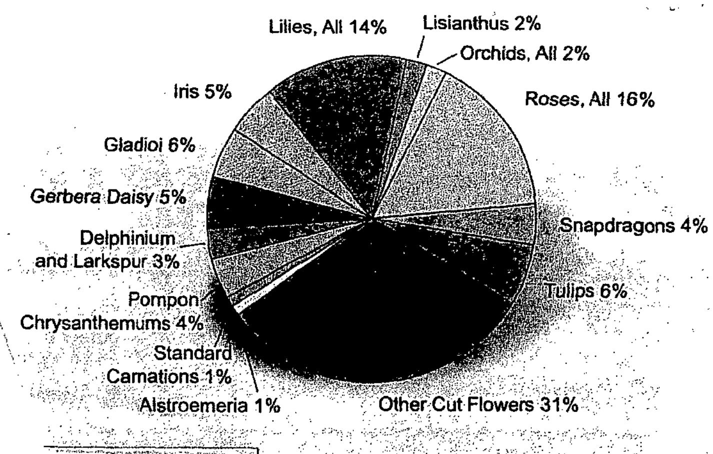


Figure 18
Sales of Cut Flowers - 2001
Dollars

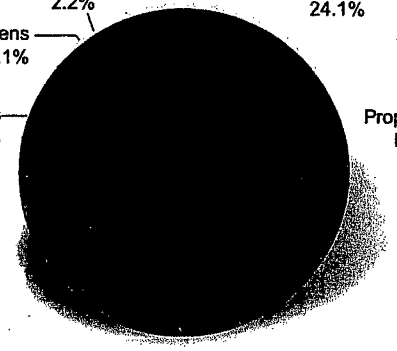
spring flowering bulbs (7.4% of units). In terms of dollars, orchids ranked second, generating 12.0% of segment sales, followed by chrysanthemums, which contributed 9.3% of the segment's dollar sales. Orchids ranked seventh in units (5.0% of units). Spring flowering bulbs contributed only 5.5% of the dollar sales, ranking sixth monetarily.

FOLIAGE PLANTS

Foliage sales increased for the fourth year in a row, rising 4.5% in 2001 from the 2000 level. Though the change in how foliage sales are reported has elevated the overall dollar levels, as Figure 16 (page 114) depicts, sales dollars for this industry segment have been generally on the rise since the early 1990s. In total, 84.6% of the segment's $585.3 million were potted foliage plants, while the remainder was in hanging baskets. Potted foliage sales increased 4.9% and foliage hanging basket sales increased 9.4% in units but only 2.4% in dollars from 2000 to 2001.

CUT FLOWERS

Cut flower sales declined for the second year in a row, dropping another 1.3% in 2001, to $424.3 million (Figure 17, page 114). Among the separately enumerated species, only gladioli lost relative importance, dropping from 7% of the segment's dollar sales in 2000 to 6% in 2001. Only lilies gained in relative importance, increasing to 14% of the segment's sales in 2001 from their 13% share of dollars in 2000. Roses remained the leading cut flower in sales (Figure 18, above), accounting for 16% of overall dollars. Lilies were the only other type to account for a double-digit share of total segment sales (13.5% of sales dollars). ▶



CUT CULTIVATED GREENS

Sales of cut greens dropped for the second year in a row, down 12.0% in 2001 to $111.1 million. Both leatherleaf ferns, which accounted for 48.9% of the segment's sales, and sales of other cut cultivated greens (51.1%) saw sales declines (18.1% and 5.2% drops, respectively). The preliminary 2001 data marks the first time that leatherleaf ferns have not accounted for the majority of this segment's sales.

PROPAGATIVE MATERIALS

New last year, numbers for the propagative materials and unfinished plants segment are still probably less than completely reliable. The reported data showed sales of $306 million for 2001, up 26.1% from the 2000 figure of $242.6 million. All industry segments except for foliage plants, reported increases in this category, and all of the increases were sizeable. Nearly half of the reported dollars in this segment (49.2%) were attributed to the annual bedding/garden plant category (Figure 19, page 120), while another 14.6% were reported for the herbaceous perennial category. Potted flowering plants accounted for 24.1% of the propagative materials, while foliage plants accounted for 9.8%. Only 2.2% of the dollars were attributed to cut flowers, and cut greens accounted for 0.1% of the dollars in this segment.

CHANGE IS A CONSTANT

While industry evolution is a constant, there are some significant issues that this year's report has highlighted. Foremost among these is the issue of growth rates. Our industry's growth rate certainly has slipped in the recent year, 2001 compared to 2000, from the 1999 to 2000 period. Yet, when one considers the recession that began in mid-2001, the 2.9% increase may be quite encouraging, especially when compared with other industries.

California's floriculture industry topping $1 billion also must be considered a milestone. In 1981, the entire *Floriculture Crops Summary* value was less than $1 billion for the 28 states surveyed at that time. The top production states increasingly dominate the overall picture.

Finally, the picture of change in various segments certainly testifies to the fact that what sells well changes over time. In the past, any bedding/garden plant produced sold well. That time is over. Today, producers must constantly alter the mix of products to sell more. Potted flowering plant producers seem to be experts at this, as there have been wide swings reported in what's produced by species, while the total unit count for the segment has changed little. This has translated into pot plant growers earning more, without increased unit production. Cut flower growers seem to be struggling with this concept, as there has been little change in the importance of various species, and dollar sales are dropping. The same seems true of cut greens producers, though there seems to be preliminary evidence of a change in what's being produced. Unfortunately, the foliage production data isn't very revealing regarding varieties, but the foliage producers must be doing something right, as their sales have now grown four years in a row, the last two of which have been at the fastest growth rates in the industry. ■

Dr. Marvin N. Miller is market research manager, Ball Horticultural Company, West Chicago, Illinois.

Outbreaks of Soybean Frogeye Leaf Spot in Iowa. X. B. Yang, M. D. Uphoff, and S. Sanogo, Department of Plant Pathology, Iowa State University, Ames 50011. Plant Dis. 85:443, 2001; published on-line as D-2001-0213-03N, 2001. Accepted for publication 16 January 2001.

Frogeye leaf spot of soybean, caused by *Cercospora sojina*, is typically a disease of warm and humid regions (2). Although the disease was reported in the Midwest in the 1920s (1), no outbreaks have been recorded in Iowa. Outbreaks of frogeye leaf spot occurred during 1999 in soybean fields in Ames and Grand Junction in central Iowa. During the 2000 growing season, the disease occurred in southwestern, south-central, central, southeastern, and east-central Iowa. Occurrences of the disease with severity (reduction of green leaf area) greater than 50% were observed in production soybean fields at Grand Junction in central Iowa and Central City in eastern Iowa. In a 12-ha no-till field planted with cv. Asgrow 2501, the disease was noticeable and uniformly distributed in the entire field in mid July. Disease severity in this field was greater than 70% by the end of August. Disease incidence, however, was less than 10% in three adjacent soybean fields. In a soybean performance test at a central Iowa location where the disease occurred in 1999 and 2000, the disease was observed on all 80 varieties, with four having a severity equal to or greater than 40%. Fourteen entries had less than a 10% disease severity and 19 entries had a disease severity equal to or greater than 30%. Infected leaves in these locations had typical lesions of frogeye leaf spot, which appeared as reddish brown margins surrounding light brown or ash gray centers. On the infected tissues, hyaline, straight, and multiseptate conidia from clustered conidiophores were found, isolated, and identified to *C. sojina*. The relatively warm winter temperatures in 1998 to 1999 and 1999 to 2000 were associated with frogeye leaf spot epidemics. Because of the seedborne nature of *C. sojina*, efforts are warranted to monitor and survey the occurrence of frogeye leaf spot in Iowa, an important seed production state in the northern soybean production region.

References: (1) K. Athow and A. H. Probst. Phytopathology 42:660-662, 1952. (2) D. V. Phillips. 1999. Pages 20-21 in: Soybean Disease Compendium. Hartman et al. eds, American Phytopathological Society. St. Paul, MN.

Isolation of an Isometric Virus Causing Sunflower Necrosis Disease in India. M. Ramiah, A. I. Bhat, R. K. Jain, R. P. Pant, Y. S. Ahlawat, K. Prabhakar, and A. Varma, Advanced Centre for Plant Virology, Division of Plant Pathology, Indian Agricultural Research Institute, New Delhi 110 012, India. Plant Dis. 85:443, 2001; published on-line as D-2001-0205-03N, 2001. Accepted for publication 18 December 2000.

Sunflower necrosis disease (SND) is becoming a potential threat to sunflower (*Helianthus annuus* L.) cultivation in the Indian subcontinent. The disease was first recorded in parts of Karnataka state in 1997. Since then the disease has become increasingly important in Andhra Pradesh, Karnataka, Maharashtra, and Tamil Nadu, the four major sunflower-growing states of India, and is a limiting factor in sunflower production; up to 80% of the plants of some open pollinated and hybrids were affected during the 1999 survey in sunflower growing areas. Field symptoms of the disease include extensive necrosis of leaf lamina, petiole, stem and floral calyx and severe stunting with malformation of flowering head when plants are infected early. The association of a tospovirus, antigenically related to groundnut bud necrosis (GBNV) and watermelon silver mottle (WSMV) viruses, with the disease has been reported (1). However, the etiology of the disease remains unaddressed. In this study a sap-transmissible isometric virus was transferred to cowpea (cvs. Pusa Komal and C152) inciting localized chlorotic and necrotic lesions and systemic veinal necrosis. Electron-microscopic studies of leaf-dip preparations from field samples revealed two types of particles (isometric measuring 25 to 28 nm in diameter and flexuous rods with a length of about 600 nm). The sap-inoculated cowpea and sunflower contained only the isometric particles. Some preparations also showed the presence of tubules containing virus particles. The presence of flexuous particles in field samples could be due to mixed infection as the mosaic disease, known to be caused by a flexuous virus, was common in the sunflower fields surveyed in the present investigations. Extracts from the field collected samples or sap-inoculated plants did not react with antisera to cucumber mosaic (CMV) or potato Y (PVY) viruses in direct antigen-coated (DAC)-ELISA and immunosorbent electron microscopy tests. The isometric virus isolated from sunflower was purified from sap-inoculated cowpea plants by differential and sucrose density-gradient centrifugations. The virus was sap transmitted back to sunflower (cv. Morden), which developed symptoms identical to those observed under field conditions. Disease symptoms were also reproduced on sunflower upon mechanical inoculation with the purified virus. Polyclonal antiserum raised in rabbits using purified virus preparations, detected the virus from field and glasshouse collected sunflower plants in DAC-ELISA tests. This will help in epidemiological studies and breeding for disease resistance. The particle size and structure and the presence of tubule containing virus particles in plant extracts suggest that the virus belongs to ILAR group. An ILAR virus is reported to infect sunflower (2), but details of its natural occurrence are not known. This is the first report on the etiology of the sunflower necrosis disease in India. Further studies are in progress.

References: (1) Anon. 2000. Annual Report (1999-2000), Indian Agricultural Research Institute, New Delhi, India. (2) A. A. Brunt et al. CAB International, Wallingford, UK, 1210, 1996.

First Report of *Fusarium solani* Causing Stunt on Lisianthus. S. Wolcan, G. Lori, and L. Ronco, CIC, CIDEFI, Facultad de Cs. Agrarias y Forestales, UNLP, 60 y 119, (1900) La Plata, Bs. As., Argentina. Plant Dis. 85:443, 2001; published on-line as D-2001-0201-02N, 2001. Accepted for publication 4 January 2001.

Fusarium solani Mart. (Sacc.) is the causal agent of stem rot and damping-off of lisianthus (*Eustoma grandiflorum* (Raf.) Shinn.) (1). Since the end of the 1980s, when this flower crop was introduced in Argentina, it has been affected by a basal stem rot (2). A previously undescribed disease was observed in 100% of the greenhouses in the Buenos Aires Province that grow lisianthus. Symptoms that developed after seedlings were transplanted included stunting, shortened internodes with reduced stem diameter, and small narrow leaves that were a dull green color. Some affected plants turned yellow-brownish and died 2 to 3 months after transplanting. Other plants recovered but produced low quality flowers later than normal. A third group of plants remained stunted (5 to 10 cm high) until the last flower harvest (about 8 to 10 months). *F. solani* was consistently isolated from basal stems and roots of diseased plants. For pathogenicity tests, inoculum was produced by culturing the fungus for 10 days in petri dishes containing sterile moistened rice. Inoculum was air dried, crushed, and mixed with soil that had been autoclaved at 112°C for 40 min on each of two consecutive days. The propagules in the soil were estimated by soil plate dilutions on the Nash & Snyder-PCNB medium at a ratio of about 10^4 CFU/g soil. Twenty plants of each cultivar Echo White and Echo Blue, whose roots had been pruned, were planted in both infested and noninfested soil. After about 40 days, stunting was observed in 85% of the inoculated plants, while controls remained asymptomatic. *F. solani* was reisolated from symptomatic plants, thus fulfilling Koch's postulates. A test also was conducted in a commercial greenhouse that produced lisianthus for several years, in which healthy plants were planted in three plots fumigated with methyl bromide and in three nonfumigated plots. The mean cfu/g soil of *F. solani* in the methyl-bromide treated plots was 5×10^2 and 1.6×10^4 CFU/g in the nontreated plot. After 120 days, the incidence of stunting in the treated plots was 0.6 and about 88% in the control plots. *F. solani* was recovered from symptomatic plants. Because disinfestation of soil is generally practiced in flower production, stunted plants are limited and can be confused with root problems. This is the first report of *F. solani* causing stunt on lisianthus.

References: (1) J. J. Taubenhaus and W. N. Ezekiel. Phytopathology 24:19, 1934. (2) S. M. Wolcan and G. A. Lori. Invest. Agr. Prot. Veg. 11:465, 1996.

(*Disease Notes* continued on next page)

Chase Research Gardens, Inc.

A.R. Chase

Plant Pathologist/President

Phone/Fax (530) 620-1624
MTAUKUM@directcon.net
www.chaseresearchgardens.com

P.O. Box 529
8031 Mt. Aukum Rd., Ste. F
Mt. Aukum, CA 95656